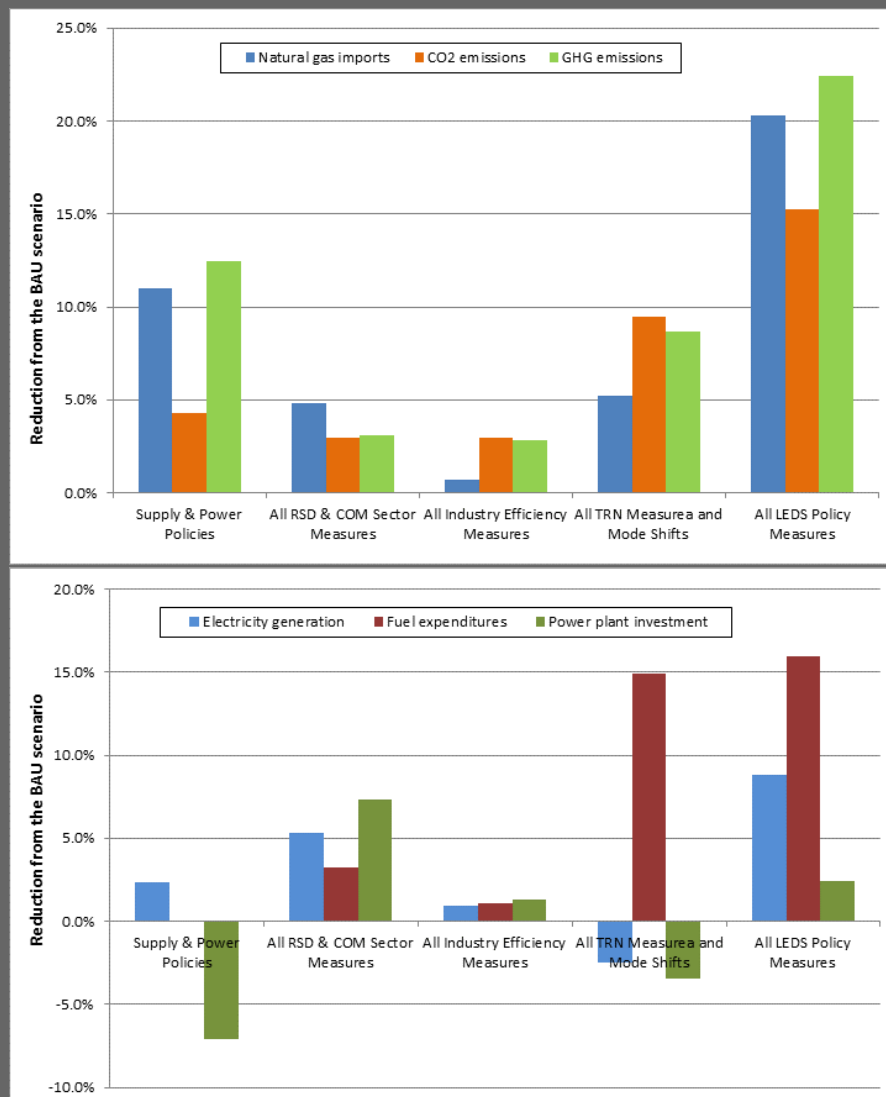




ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDS) CLEAN ENERGY PROGRAM

COOPERATIVE AGREEMENT NO. 114-A-13-00008

MARKAL-Georgia Mitigation Measures Report



May 2016

This publication was produced for review by the United States Agency for International Development. It was prepared by Winrock International in cooperation with Decision Ware Group LLC

ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES (EC-LEDs) CLEAN ENERGY PROGRAM

MARKAL-Georgia Mitigation Measures Report

MAY 2016

DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

TABLE OF CONTENTS

TABLE OF CONTENTS.....	III
LIST OF FIGURES.....	III
LIST OF TABLES.....	IV
ACRONYMS.....	V
1 EXECUTIVE SUMMARY.....	I
2 INTRODUCTION.....	2
3 MARKAL-GEORGIA OVERVIEW.....	3
4 LEDS BUSINESS AS USUAL (BAU) SCENARIO.....	5
6 SUPPLY AND POWER SECTOR.....	6
6.1 Description of Mitigation Measures.....	6
6.2 Mitigation Measures Impact Summary.....	6
7 BUILDING SECTORS ENERGY USE AND GHG EMISSIONS.....	9
7.1 Description of Mitigation Measures.....	9
7.2 Mitigation Measures Impact Summary.....	10
8 INDUSTRY SECTOR ENERGY USE AND GHG EMISSIONS.....	15
8.1 Description of Mitigation Measures.....	15
8.2 Mitigation Measures Impact Summary.....	16
9 TRANSPORTATION SECTOR ENERGY USE AND GHG EMISSIONS.....	21
9.1 Description of Mitigation Measures.....	21
9.2 Mitigation Measures Impact Summary.....	22
10 ALL SECTORS COMBINED.....	28
APPENDIX A: DETAILED RESULTS OF ALL LEDS MEASURES.....	30
A.1 - Supply and Power Sector.....	30
A.2 - Buildings Sector.....	31
A.3 - Industry Sector.....	34
A.4 - Transport Sector.....	37
A.5 - Combined Sectoral Measures.....	41

LIST OF FIGURES

Figure 1: Impacts of Sectoral and Combined LEDS Measure - 1.....	I
Figure 2: Impacts of Sectoral and Combined LEDS Measure – 2.....	2
Figure 1: Simplified Reference Energy System.....	4
Figure 2: Supply and Power Sector Measure Impacts - 1.....	8
Figure 3: Supply and Power Sector Measure Impacts - 2.....	8
Figure 4: Change in Electricity Generation from the BAU for select Power Sector Policies.....	9
Figure 5: Lighting, Appliance & Renewables Measure Impacts - 1.....	13
Figure 6: Lighting, Appliance & Renewables Measure Impacts - 2.....	13
Figure 7: Commercial and Residential Building Shell Measure Impacts - 1.....	14
Figure 8: Commercial and Residential Building Shell Measure Impacts - 2.....	14
Figure 9: Chemicals, Food and Iron & Steel Industry Measure Impacts - 1.....	19
Figure 10: Chemicals, Food and Iron & Steel Industry Measure Impacts – 2.....	19
Figure 11: Cement, Combined and Pig Iron Industry Measure Impacts - 1.....	20
Figure 12: Cement, Combined and Pig Iron Industry Measure Impacts - 2.....	20
Figure 13: Transport Sector Measure Impacts - 1.....	26
Figure 14: Transport Sector Measure Impacts - 2.....	26

Figure 15: Transport Sector Measure Impacts - 3.....	27
Figure 18: Transport Sector Measure Impacts - 4.....	27
Figure 19: Sectoral and Combined LEDS Measure Impacts - 1	29
Figure 20: Sectoral and Combined LEDS Measure Impacts - 2	29

LIST OF TABLES

Table 1: BAU Scenario Parameters	5
Table 2: Supply and Power Sector Measures.....	6
Table 3: Summary Results of Supply and Power Sector Measures.....	7
Table 4: Buildings Sector Measures.....	9
Table 5: Summary Results of Buildings Sector Measures.....	11
Table 6: Industry Sector Measures.....	15
Table 7: Summary Results of Industry Sector Measures.....	17
Table 8: Transportation Sector Measures.....	21
Table 9: Summary Results of Transportation Sector Measures.....	24
Table 10: Summary of Results for Sectoral and All LEDS Measures.....	28

ACRONYMS

BAU	Business-as-Usual
BEUR	Billion Euro
CH ₄	Methane
CNG	Compressed Natural Gas
CO ₂	Carbon Dioxide
COP	Conference of the Parties
EC-LEDs	Enhanced Capacity – Low Emissions Development Strategy
GfG	Governing for Growth
GDP	Gross Domestic Product
Gg	Gigagram
GOG	Government of Georgia
GWh	Gigawatt Hours
GWP	Global Warming Potential
GHG	Greenhouse Gas
HPEP	Hydro Power and Energy Planning
IEA-ETSAP	International Energy Agency's Energy Technology Systems Analysis Programme
INDC	Indicative National Determined Contribution
Kt	Thousand Tons
Ktoe	Thousand Tons Oil Equivalent
LDV	Light Duty Vehicle
MARKAL	MARKet Allocation
MEUR	Million Euro
MoE-AD	Ministry of Energy Analytical Department
MW	Megawatts
N ₂ O	Nitrous Oxide
NDC	National Determined Contribution
NMVOC	Non-methane volatile organic compounds
PJ	Petajoules
PJa	Petajoules per annum
REDP	Regional Energy Demand Planning
RES	Reference Energy System
RESMD	Regional Energy Security and Market Development
SC	Steering Committee (LEDs)
SEAP	Sustainable Energy Action Plan
UNFCCC	United Nations Framework Convention on Climate Change
USAID	US Agency for International Development
WG	Working Group (LEDs)

1 EXECUTIVE SUMMARY

This report was prepared under the US Agency for International Development (USAID) Enhancing Capacity for Low Emissions Development Strategy (EC-LEDS) Clean Energy Program for Georgia, which supports increased climate change mitigation by building capacity to stimulate private sector investment in energy efficiency and green buildings, raising public awareness, and strengthening Government of Georgia (GOG) capacity to develop and implement a national LEDS.

This report builds on the BAU scenario report that describes the energy and emissions aspects of the BAU scenario for Georgia as a whole, and for each supply and demand sector. This report summarizes analyses that were performed to determine the impact of possible LEDS measures, as well as determine the aggregated impact of groups of measures bundled together as sector policies.

The analyses presented in this report were performed using the MARKAL-Georgia model and the best available local data, augmented by international data for future technology characterizations. The sector-specific LEDS measures were identified by the WGs as the most feasible and implementable options for Georgia, and the model calculated the quantitative metrics of the impacts of each options, as well as the aggregated impact when several potentially overlapping measures are combined.

The aggregated impacts of each sectoral combination and the combination of all LEDS measures are shown in Figure 1 and

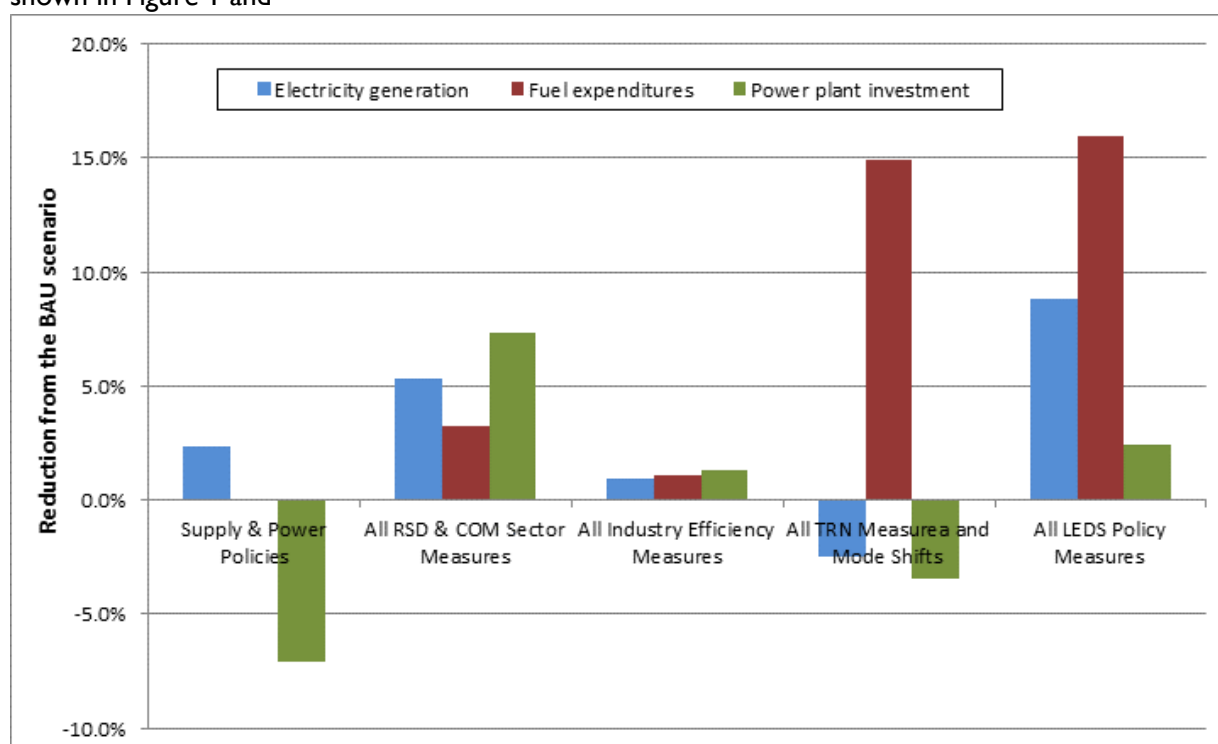


Figure 2. Natural gas imports are reduced by 20% overall, with 11% of that reduction coming from the Supply and Power sector, and the Buildings and Transportation sectors contributing about 5% each. Fuel expenditures are reduced by 16% with most of that coming from the Transportation sector, with Buildings and Industry sectors contributing about 3% and 1% respectively.

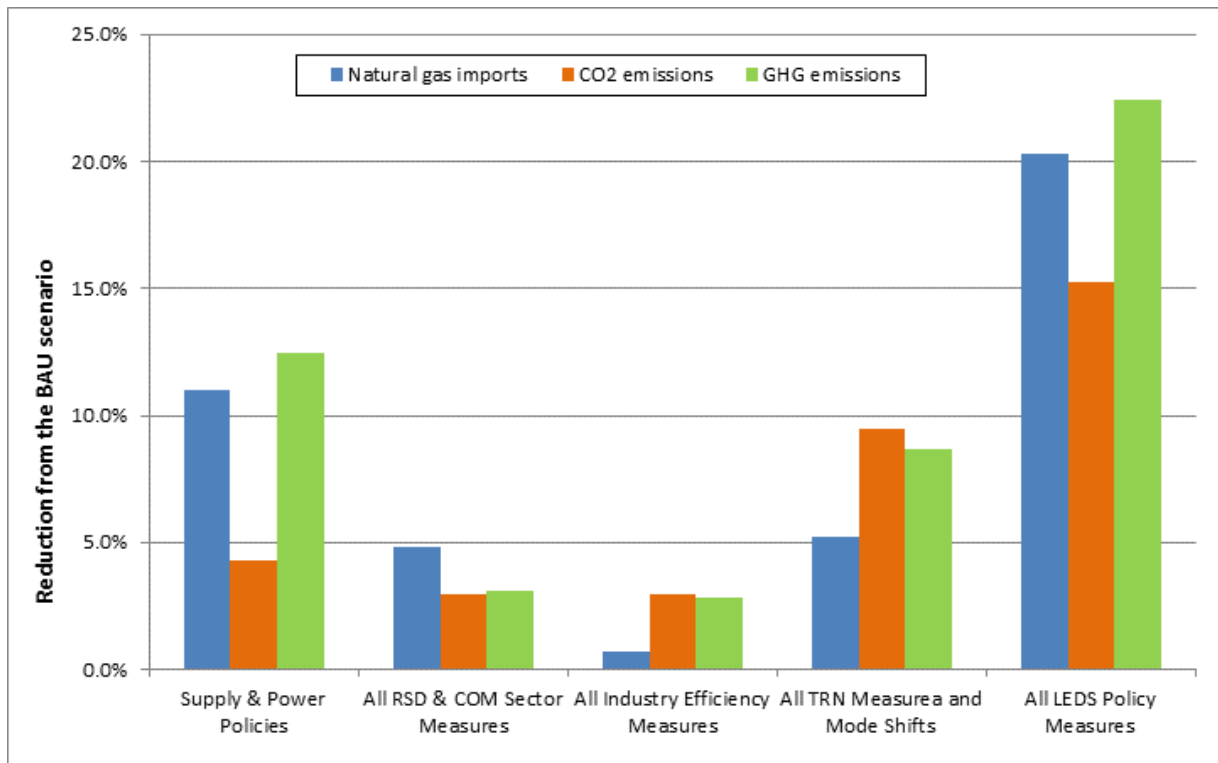


Figure 1: Impacts of Sectoral and Combined LEDS Measure - I

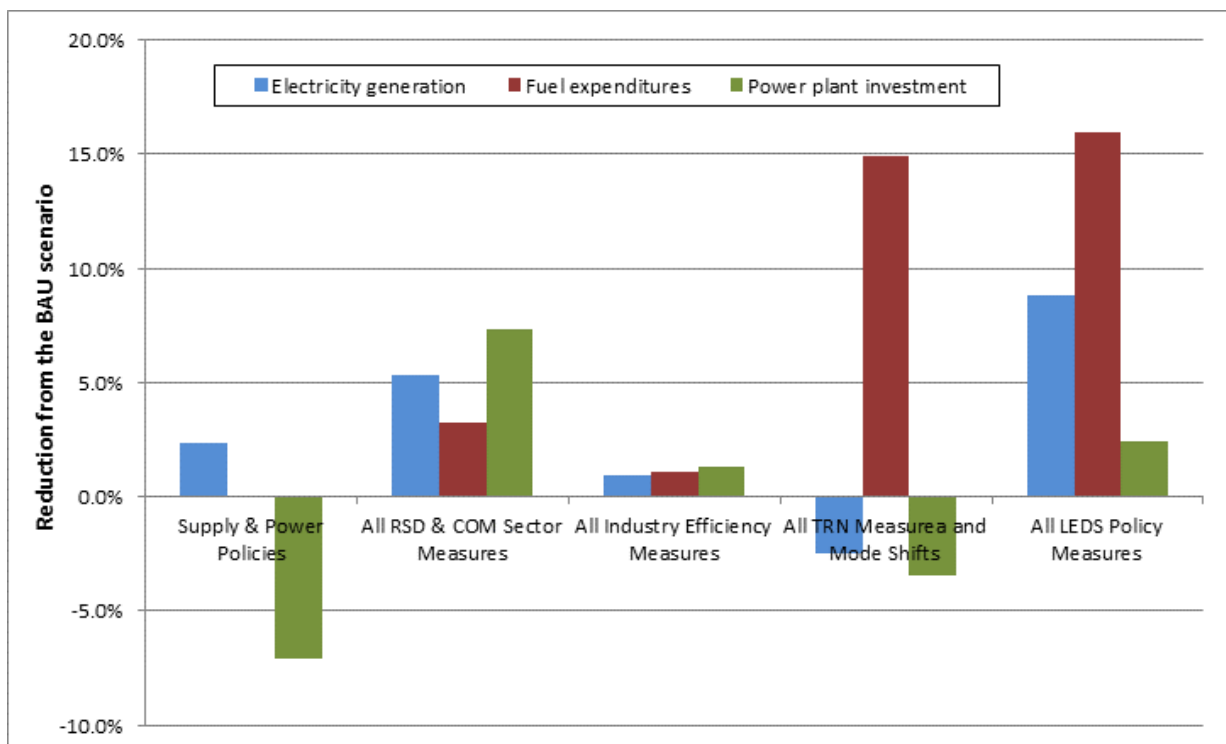


Figure 2: Impacts of Sectoral and Combined LEDS Measure - 2

Electricity generation is reduced in all the sectors except Transportation, with a net reduction of 9%. Power plant investment shows a modest net reduction (2.5%), with increased investments from the Power and Transport sectors offset by the savings from the Buildings and Industry sectors.

CO₂ emissions are reduced by 15% with Transportation making the largest contribution followed by Power, Industry and Buildings. GHG emissions, which include methane emissions, are reduced more than 22%, with the Power sector producing the greatest contribution due to a measure to reduce natural gas distribution system losses.

This report provides similar details on the individual measures from each sector, and is intended to provide the analytic underpinning of a LEDS roadmap for Georgia. It has been developed as part of advising the LEDS SC and WGs, and to continue the process of enhancing the local capacity to identify the most effective policies for NDC implementation.

2 INTRODUCTION

The US Agency for International Development (USAID) Enhancing Capacity for Low Emissions Development Strategy (EC-LEDS) Clean Energy Program for Georgia supports increased climate change mitigation by building capacity to stimulate private sector investment in energy efficiency and green buildings, raising public awareness, and strengthening Government of Georgia (GOG) capacity to develop and implement a national LEDS. Under Component 3, the EC-LEDS Clean Energy Program is supporting the National EC-LEDS Steering Committee (SC) and associated technical working groups (WGs.) by providing advisory assistance to the GOG to articulate concrete actions, policies, programs and implementation plans under the US-Georgia bilateral EC-LEDS initiative, including supporting Georgia's preparation of policy measures needed to achieve their Nationally Determined Contribution (NDC) as submitted to the United Nations Framework Convention on Climate Change (UNFCCC) 21st Conference of Parties (COP-21) in Paris December 2015.

This report documents work performed by DecisionWare Group (DWG) and Sustainable Development Center Remissia in cooperation with Winrock International, leader of the EC-LEDS Clean Energy Program and the Ministry of Energy Analytical Department (MoE-AD) to analyze a large number of policy measures using the updated MARKAL-Georgia energy system planning model to help identify those deemed most attractive for Georgia's LEDS pathway.

This report summarizes this analysis, both in terms of the impact of individual measures, as well as the aggregated impact of groups of measures bundled together as sector policies. The report focuses on the change in energy consumption, investment requirements, and Greenhouse Gas Emissions (GHG) emissions relative to the Business-as-Usual (BAU) scenario. The analyses presented in this report were performed using the best available local data, augmented by international data for future technology characterizations. The sector-specific LEDS measures were identified by the WGs as the most feasible and implementable options for Georgia, and the model provides quantitative measures of the impacts of each options, as well as the aggregated impact when several potentially overlapping measures are combined.

This report builds on the BAU scenario report¹ that describes the energy and emissions aspects of the BAU scenario for Georgia as a whole, and for each supply and demand sector. Therefore, this report only summarizes the BAU scenario results, particularly those metrics that will be used to characterize the performance of the measures in each sector.

This report is intended to provide the analytic underpinning of a LEDS roadmap for Georgia. It has been developed as part of advising the LEDS SC and WGs, and to continue the process of enhancing the capacity of the MoE-AD towards ownership and responsibility for the stewardship of MARKAL-Georgia going forward.

¹ USAID, Enhancing Capacity For Low Emission Development Strategies (EC-LEDS) Clean Energy Program Georgia, Updated MARKAL-Georgia BAU Scenario Report, April 2016.

3 MARKAL-GEORGIA OVERVIEW

The MARKAL-Georgia model has been developed over several years with the support of a series of USAID regional and national projects designed to better inform policy making and assess future energy investment options. It is built using the MARKAL integrated energy system modeling platform, developed under the auspices of the International Energy Agency's Energy Technology Systems Analysis Program (IEA-ETSAP, www.iea-etsap.org). The MARKAL-Georgia model has been used to examine the role of energy efficiency and renewable energy in meeting anticipated Energy Community commitments and European Union accession directives. The model was also used for energy strategy analysis as part of the USAID Hydro Power and Energy Planning (HPEP) project. Most recently under this EC-LEDS project, the model was used to develop the BAU trajectory for the energy sector for Georgia's submission to COP-21.

The key features of a MARKAL model are:

- Encompasses the **entire energy system** from resource extraction through to end-use demands as represented by a Reference Energy System (RES) network (see the example in Figure 3);
- Employs least-cost **optimization**;
- Identifies the most **cost-effective** pattern of resource use and technology deployment over time;
- Provides a framework for the evaluation of mid-to-long-term **policies and programs** that can impact the evolution of the energy system;
- Quantifies the **costs and technology choices**, and the associated emissions, that result from imposition of the policies and programs, and
- Fosters **stakeholder buy-in** and consensus building.

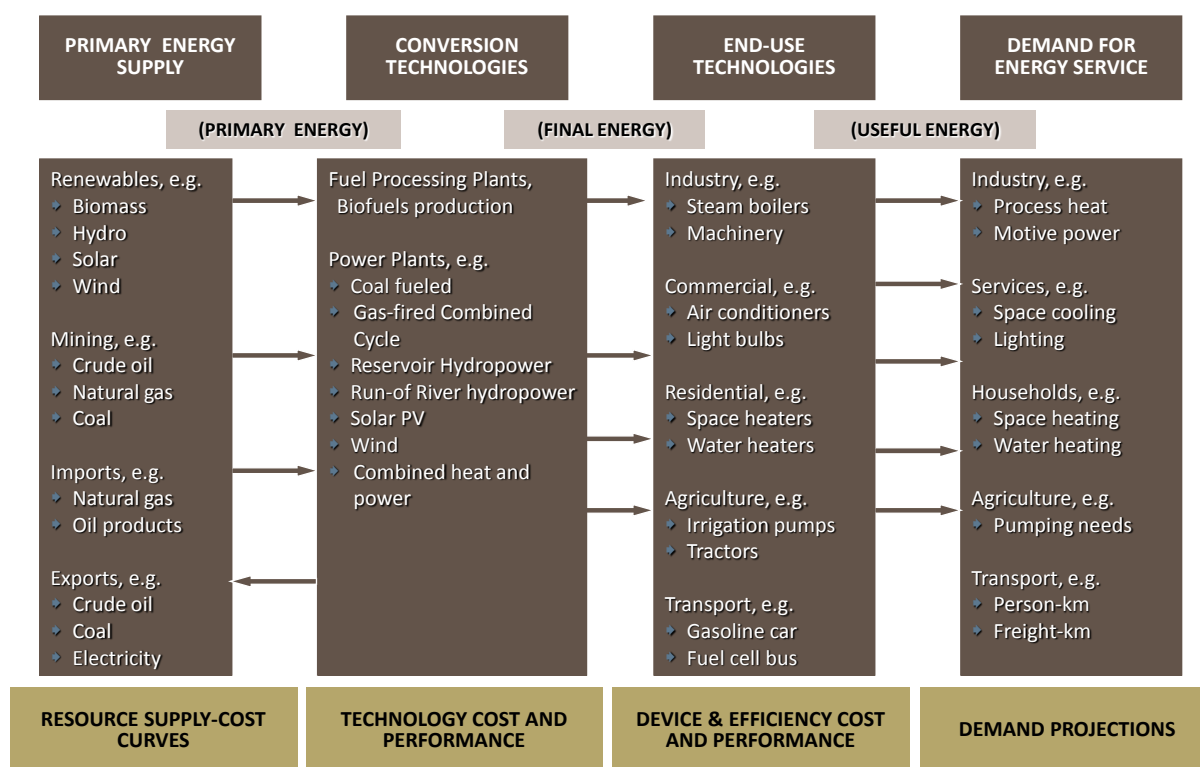


Figure 3: Simplified Reference Energy System

Under the current phase of EC-LEDS project the MARKAL-Georgia model has been substantially revised and updated. The major change involved moving the model's Base Year to 2014 and

calibrating the model to the 2014 Geostat energy balance, which is an improvement over the 2012 and 2013 energy balances. In addition, the model was restructured into 2-year periods out to 2040, compared to 3-year periods out to 2036 in the previous version. Furthermore, all input data were reviewed and updated where appropriate. A summary of these changes may be found in Appendix A of the BAU Report¹.

Based on 2014 Geostat energy balance, there are 25 different forms of energy currently used in Georgia, each fully depicted in the model. These energy carriers are utilized in the following demand sectors:

- Residential
- Commercial
- Industry
- Transportation
- Agriculture
- Territory Electricity Demand (TED), representing the electricity consumption in Abkhazia.

In addition, there is a separate sector representing the non-energy demands to fully represent all the entries in the 2014 Geostat energy balance.

The power sector describes Georgia's existing and planned power plants individually, including the three thermal plants currently in operation, the Enguri and Vardnili regulating hydro plants, run of river hydropower plants, as well as potential new coal and natural gas-fired power plants.

4 LEDS BUSINESS AS USUAL (BAU) SCENARIO

The MARKAL-Georgia BAU scenario represents the expected evolution of the Georgia energy system under current policies and practices. The BAU scenario does not represent a forecast of evolution of energy system; rather it serves as the comparison scenario for quantifying the costs, benefits, technology changes, fuel switching, emissions and other impacts of potential measures that collectively will shape the LEDS strategy for Georgia. Table I presents the primary energy and emissions results for the BAU scenario showing the change between 2014 and 2030.

Table I: BAU Scenario Parameters

Indicator	Units	2014	2030	Growth
GDP	2014M€	12,436	28,566	130%
Primary Energy Supply	Ktoe	4,587	9,770	113%
All Imports	Ktoe	3,224	6,384	98%
Natural gas Imports	Ktoe	1,825	3,627	99%
Net Electricity exports	GWh	-248	13,529	NA
Fuel Expenditure	2014M€	1225	2,773	126%
Power Plant Capacity	MW	3,431	8,780	156%
Hydro Power Plant Capacity	MW	2,751	7,684	179%
Thermal (gas and coal) Power Plant Capacity	MW	680	1,075	58%
Renewable Power Plant Capacity	MW	0.00	0.02	NA
Electricity generation	GWh	10,383	17,851	72%
Power Plant New Capacity (2014-2030)	MW	NA	5,350	NA
Power Plant Investment Cost (2014-2030)	2014M€	NA	8,049	NA
Total Final Energy	Ktoe	3,821	7,207	89%
Transport Final Energy	Ktoe	1,328	2,731	106%
Buildings Sector Final Energy	Ktoe	1,628	2,092	29%
Industry Final Energy	Ktoe	712	1,468	106%
Total CO2 Emissions	Kt	7,907	15,994	102%

Transport sector CO ₂ Emissions	Kt	3,458	6,709	94%
Buildings sector CO ₂ Emissions	Kt	1,673	2,816	68%
Industry sector CO ₂ Emissions	Kt	1,630	3,461	112%
Power sector CO ₂ Emissions	Kt	1,121	2,111	88%
Total Methane Emissions	Kt	70	140	101%
Total N ₂ O Emissions	Kt	0.19	0.33	69%
Total GHG emissions	Kt CO ₂ eq	9,421	19,025	102%

The sections that follow present for each sector the mitigation measures being investigated and provide a summary of their impact. The full set of preliminary results from these mitigation measures is provided in an accompanying Excel Workbook.

6 SUPPLY AND POWER SECTOR

6.1 Description of Mitigation Measures

The measures for the supply and power sectors include reducing natural gas losses, improving power plant efficiency, promoting hydropower and as well as other renewables. In addition, one scenario looks at the combined effect of all the measures for this sector. Each is briefly described in Table 2.

Table 2: Supply and Power Sector Measures

Measure	Description
Reduce natural gas distribution losses	Assumes investment to reduce gas losses in the distribution system from 6% in 2014 to 2% by 2030.
More efficient thermal generation	Two existing inefficient gas-fired power plants are replaced with modern, efficient combined cycle power plants.
Promotion of Hydropower	Improvements to the electric T&D system are made which allows an increase in the share of hydro generation serving the load.
Promote renewable generation	Assumes 150MW of wind farm and 50MW of solar PV are in place by 2025.
All supply and power sector measures	Combines all supply and power sector measures.

6.2 Mitigation Measures Impact Summary

The results from the Power & Supply Sector mitigation measures selected to illustrate the impacts on these measures include natural gas imports, energy-sector CO₂ and total GHG emissions, as well as electricity generation, fuel expenditures and power plant investments. The results are described below and summarized in Table 3. Appendix A provides a detailed table of results.

The measure to reduce natural gas distribution losses reduces gas imports by 2.7%, and lowers total GHG emissions by 8.5%, due to the reduction in methane emissions. There was no change in fuel expenditures, power plant investment, or generation mix. The measure to implement more efficient gas power plants (replacing Mtkvari Unit 9 and Tblsrese Units 3+4) with 500 MW of new gas combined cycle power plants reduces gas imports by 4.5% and GHG emissions by 2.5%. Fuel costs are reduced by 58 million EUR (MEUR) in 2030, with power plant investment increasing by 258 MEUR relative to the BAU.

Strengthening the electric transmission grid to lower the gas power plant balancing requirement leads to greater generation from hydropower as arising from 130 MW of additional hydropower capacity. Natural gas imports are reduced by 3.5% and GHG emissions by 2.6%. Fuel costs are reduced by 30 MEUR in 2030, with power plant investment increasing by 224 MEUR.

The measure to require more non-hydropower renewables, in particular solar PV and wind, shows that these resources displace hydropower generation and lower exports. As a result they do not produce any reductions in GHG emission or natural gas imports. Fuel costs are reduced by only 4 MEUR in 2030, with power plant investment increasing by 201 MEUR. This measure requires more investigation in terms of seasonal availability of wind farms and their ability to reduce emissions

The combined supply and power sector measures reduce natural gas imports by 11% and lowers GHG emissions by 12.5%. Fuel costs are reduced by 104 MEUR in 2030, and power plant investment increases by 573 MEUR. The GHG reduction in 2030 is 2.375 Mt CO₂eg, which is

comprised of 690 kt of CO₂ emission reductions and 80 kt of methane emission reductions. These results are summarized Table 3.

Table 3: Summary Results of Supply and Power Sector Measures

Measure	Description
Reduce natural gas distribution losses	<ul style="list-style-type: none"> • Reduces gas imports by 2.7% and total GHG emissions by 8.5%, due to the reduction in fugitive methane emissions. • Fuel costs are reduced by 36 MEUR in 2030. • No impact to power plant investments.
More efficient thermal generation	<ul style="list-style-type: none"> • Reduces gas imports by 4.5% and GHG emissions by 2.5%. • Fuel costs are reduced by 58 MEUR in 2030. • Increases power plant investment by 258 MEUR.
Promotion of Hydropower	<ul style="list-style-type: none"> • Reduces gas imports by 3.5% and GHG emissions by 2.6%. • Fuel costs are reduced by 30 MEUR in 2030. • Increases power plant investment by 224 MEUR.
Promote renewable generation	<ul style="list-style-type: none"> • Produce no reductions in natural gas imports or GHG emissions. • Fuel costs are reduced by only 4 MEUR in 2030. • Increases power plant investment by 201 MEUR.
All supply and power sector measures	<ul style="list-style-type: none"> • Reduce natural gas imports by 11% and lowers GHG emissions by 12.5%. • Fuel costs are reduced by 104 MEUR in 2030. • Increases power plant investment by 573 MEUR.

Figure 4 shows the reductions in natural gas imports, CO₂ and GHG emissions for the Supply and Power sector measures, while Figure 5 shows the reductions in electricity generation, fuel expenditures and power plant investments. Note that the most of these scenarios increase power plant investment, while one increases electricity generation.

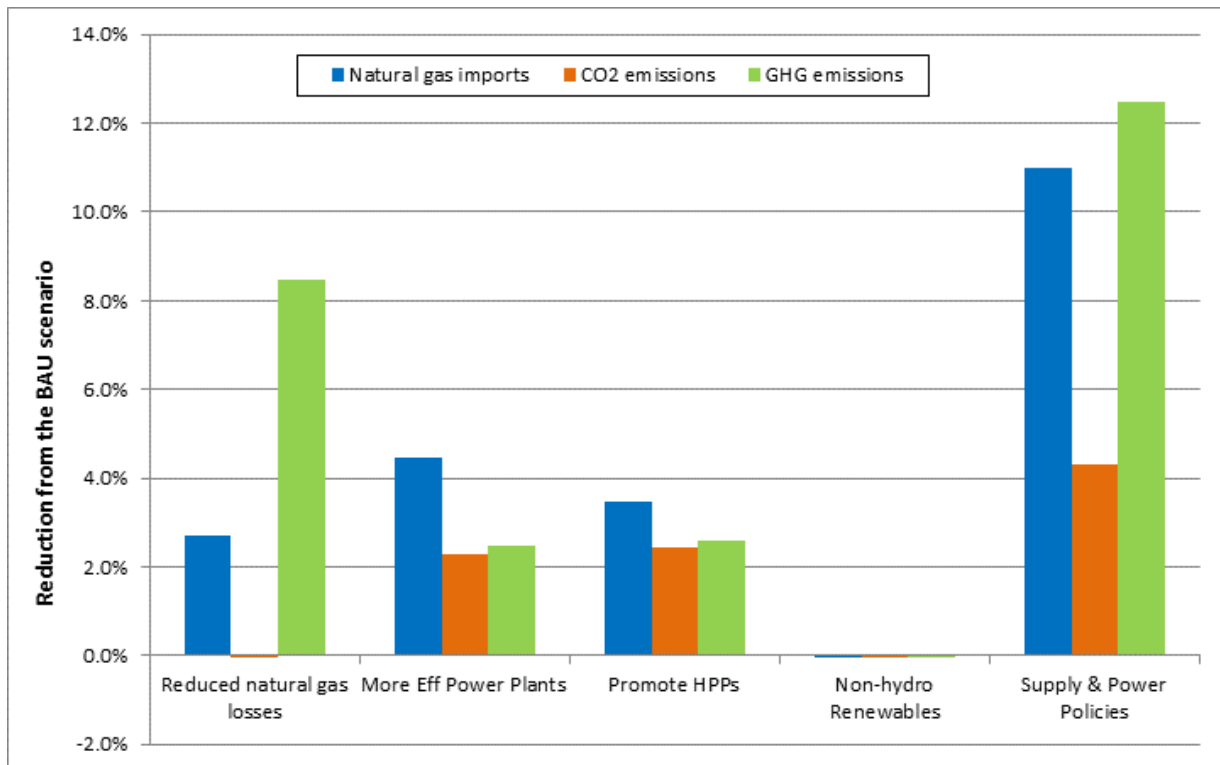


Figure 4: Supply and Power Sector Measure Impacts - 1

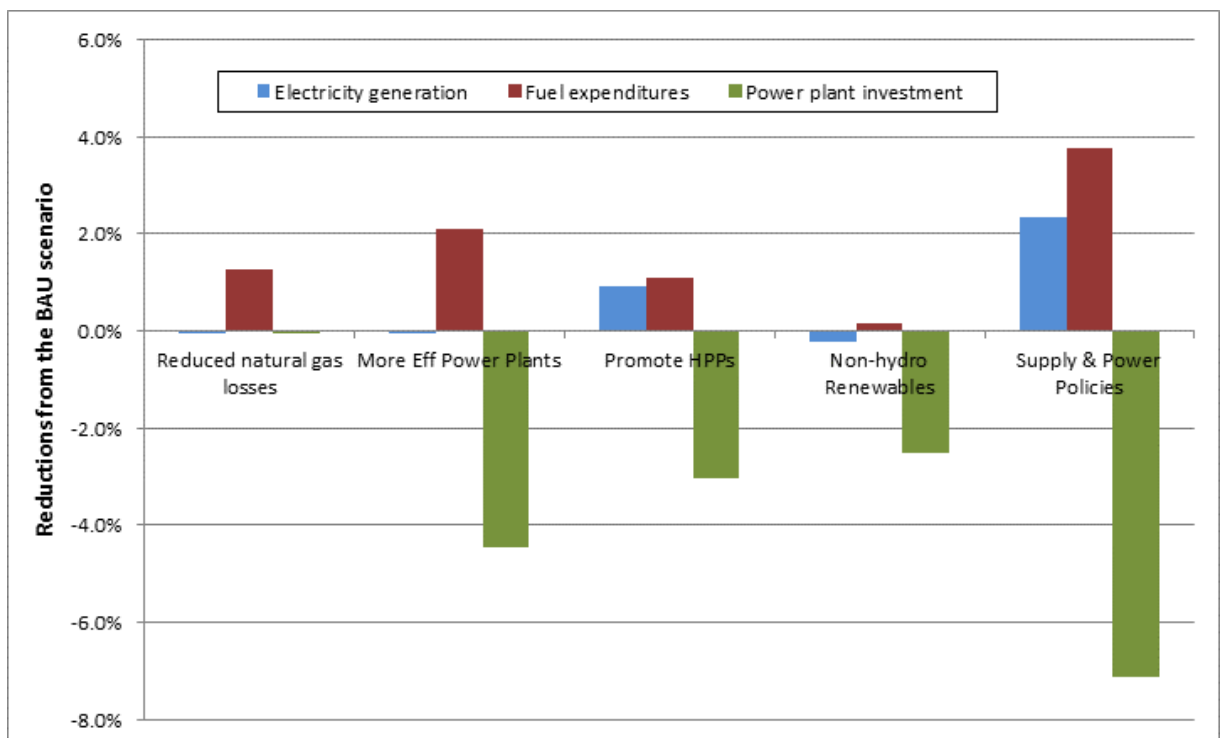


Figure 5: Supply and Power Sector Measure Impacts - 2

The interplay between the various sector components under the different policy regimes, as explained above, can be readily seen in Figure 6, which shows the change in electricity generation mix for three of the power sector policies relative to the BAU scenario.

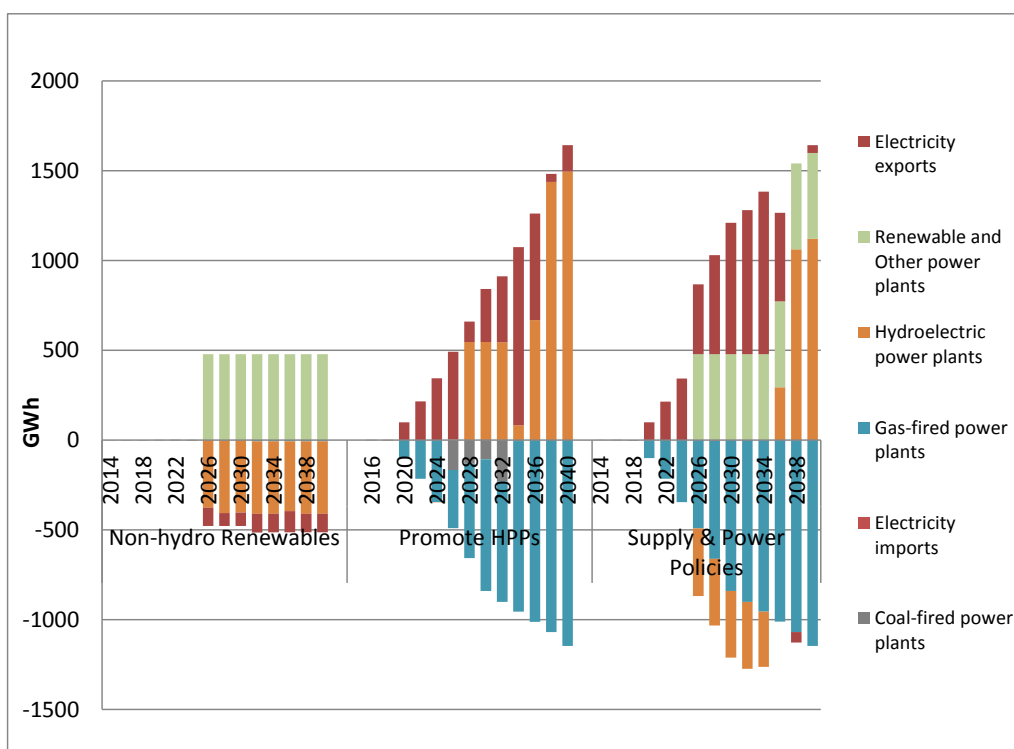


Figure 6: Change in Electricity Generation from the BAU for select Power Sector Policies

7 BUILDING SECTORS ENERGY USE AND GHG EMISSIONS

7.1 Description of Mitigation Measures

In MARKAL-Georgia the buildings sector consists of commercial (state owned and private) and residential (households) buildings, as well as public lighting. There are ten individual measures and three combination runs. The individual measures include efficient lighting, appliance labeling, energy efficiency retrofits for existing buildings as well as new construction, and the promotion of solar water heaters and modern efficient biomass heating stoves. Of the three combination runs, one bundles the building shell measures, another the remaining appliance and device measures, and the third bundles all the measures. These are described in more detail in Table 4.

Table 4: Buildings Sector Measures

Name	Description
Efficient lighting (phase out Incandescent bulbs)	Reduce the use of incandescence bulbs to zero by 2022, thereby promoting the use of more efficient bulbs.
Labeling of appliances	Labeling of electric appliances to encourage increased penetration of more advanced technologies such that they comprise 50% of new purchases in 2030.
NAMA for public buildings	Use of energy service contracting for complete renovation of public buildings (9% of all commercial buildings) reaching 50% of such buildings in 2030.
Commercial building retrofits	Promote energy efficiency retrofit measures for private commercial buildings so that 20% of such buildings are retrofitted by 2030.

New building code	New building codes with efficiency standards for both residential and commercial new buildings leading to a 20% improvement compared to existing buildings in all new buildings by 2030.
NAMA for residential buildings	Use of energy service contracting for complete renovation of existing residential buildings such that 5% are renovated by 2030.
NAMA for solar water heating	Promote installation of solar water heaters in residential houses leading to a 30% share of all new water heaters by 2030.
NAMA for advanced biomass heating stoves	Promote installation of efficient biomass heating stoves for rural households leading to an 80% share of new biomass heating stove by 2030.
Promote solar water heating in commercial sector	Promotion of solar water heaters in the commercial sector leading to a 20% share of all commercial water heaters by 2030.
LED lamps for public lighting	Requires that 90% of all public lighting fixtures are replaced with LED bulbs by 2030.
Renewables, appliance & lighting efficiency	Combines the NAMAs for solar and biomass, appliance labeling, and both lighting measures.
All Building Retrofits	Combines all commercial and residential building retrofit and insulation measures.
All RSD & COM Sector Measures	Combines all commercial and residential mitigation measures.

7.2 Mitigation Measures Impact Summary

The results from the Buildings Sector mitigation measures selected to illustrate the impacts on these measures include electricity generation, power plant investments, fuel expenditures, emission reductions and natural gas imports. Building sector direct CO₂ emission reductions are generally small, as the overall penetration of insulation measures, especially for residential buildings is not very high, because of significant barriers in this sector, and also because many of the measures impact electricity consumption. The results are described below and summarized in Table 5. Appendix A provides a detailed table of results.

Phasing out incandescent light bulbs saves the Georgian economy 706 MEUR between 2014 and 2030. Electricity generation is reduced by 5% in 2030, and power plant investment is reduced by 560 MEUR between now and 2030. Gas imports are reduced by 1.5%, and power sector CO₂ emissions drop by almost 6%, although overall GHG emissions drop only by 0.8% because power sector emissions are a relatively small percentage of total GHG emissions in Georgia.

Appliance labelling leads to a 2.3% reduction in electricity generation in 2030, a 0.6% decrease in gas imports, and an energy system cost savings of 85 MEUR, as the increased cost of the more efficient appliances is more than offset by the reductions in electricity expenditures. Power plant investment is reduced by 264 MEUR, while overall GHG emissions are reduced by 0.3%.

Public building retrofits impact a small percentage of all commercial buildings. Therefore, the measure has a small impact, reducing GHG emissions by 0.1% in 2030. There is a slight decrease in energy system costs as the increased cost of the building retrofits is offset by the reductions in energy system costs. Commercial building retrofits impact a larger percentage of commercial buildings, and reduce gas imports by 0.6%, fuel costs and GHG emissions by 0.3% in 2030, and the energy system cost is reduced by 33 MEUR.

Implementing new building codes and standards for commercial and residential buildings achieves a 0.5% reduction in total GHG emissions in 2030 (92 kt CO₂ eq.). Gas imports are reduced by 0.7%, and the energy system cost is reduced by 22 MEUR.

Installing thermal insulation in existing residential buildings decreases final energy use by 2.1% and gas imports by 0.9%. Fuel costs and total GHG emissions are both reduced by 0.7% in 2030. The energy system cost increases by 37 MEUR as the cost of the insulation measures is not fully offset by the energy costs savings.

Promoting solar water heaters for urban households reduces building sector final energy use by 0.5% and fuel costs by 0.4% in 2030, but increases electricity generation by 0.3% as the solar water heaters displace gas and use electricity for back-up. Overall GHG emissions are reduced by 0.2%. System cost increases by 10 MEUR due to the higher cost of the solar water heaters.

Advanced biomass heating stoves reduce energy use for rural heating by 0.8% (mostly gas and LPG), which lowers gas imports by 0.3% and total fuel costs by 0.3%. There is a small reduction in power plant investment, and GHG emissions are reduced by 0.2% (46 kt) in 2030. System cost increases by 76 MEUR due to the higher cost of the stoves.

Commercial solar water heating reduce natural gas imports by 0.2% and fuel costs and GHG emissions by 0.1% in 2030. Electricity generation and power plant investments go up slightly in 2030.

Switching public lighting to LED bulbs saves almost 27 MEUR over the planning horizon. Electricity generation is reduced by 0.4% (120 GWh) in 2030, and power plant investments are reduced by 45 MEUR. GHG emissions reductions are very small as mostly hydropower generation is reduced.

Combining all the renewable energy, appliance, and lighting efficiency measures reduces final energy use in buildings by 4.1% and achieves a 1.8% reduction in GHG emissions (352 kt CO₂eq) in 2030. System costs is reduced by 1.2% (721 MEUR), and electricity generation is reduced by 2.25 TWh in 2030. Power plant investment is reduced by 10% (811 MEUR). System cost decreases by 38 MEUR.

Combining all commercial and residential building retrofits (and insulation) measures, reduces natural gas imports by 2.6%, fuel expenditures by 1.7% in 2030, with a 0.1% reduction in electricity generation and power plant investment costs. GHG emissions are reduced by 1.7% (322 kt) in 2030.

All Building sector measures reduces natural gas imports by 4.8%, electricity generation by 5.3% and GHG emissions by 3.1% (592 kt) in 2030. Fuel expenditures are reduced by 3.3% and power plant investment is reduced by 591 MEUR. System cost decreases by 682 MEUR.

Table 5: Summary Results of Buildings Sector Measures

Name	Description
Efficient lighting (phase out Incandescent bulbs)	<ul style="list-style-type: none"> Saves over 700 MEUR in energy system costs. Reduces electricity generation by 5% in 2030, and power sector CO₂ emissions by almost 6%. Power plant investment is reduced by 560 million EUR, and gas imports are reduced by 1.5%. Building sector energy use 2.8%.
Labeling of appliances	<ul style="list-style-type: none"> Reduces electricity generation by 2.3% in 2030, gas imports by 0.6%, and generates energy system cost savings of 85 MEUR over the planning horizon. Power plant investment is reduced by 264 MEUR, while overall GHG emissions are reduced by 0.3%.
NAMA for public buildings	<ul style="list-style-type: none"> Reduces GHG emissions by 0.1% in 2030. Energy system cost does not change significantly as the increased cost of the building retrofits is offset by the reductions in fuel costs.
Commercial building retrofits	<ul style="list-style-type: none"> Reduces gas imports by 0.6%, and fuel costs and GHG emissions by 0.3% in 2030. Energy system cost is reduced by 22 MEUR.

New building code	<ul style="list-style-type: none"> • Achieves a 0.5% reduction in total GHG emissions in 2030 (92 kt CO₂ eq.). • Gas imports are reduced by 0.7%, and the energy system cost is reduced by 22 MEUR.
NAMA for residential buildings	<ul style="list-style-type: none"> • Decreases building final energy use by 2.1% and gas imports by 0.9%. • Fuel costs and total GHG emissions are both reduced by 0.7% in 2030. • Energy system cost increases by 37 MEUR.
NAMA for solar water heating	<ul style="list-style-type: none"> • Reduces building sector final energy use by 0.5% and fuel costs by 0.4% in 2030. • Increases electricity generation by 0.3% as the solar water heaters displace gas and use electricity for back-up. • Overall GHG emissions are reduced by 0.2%.
NAMA for advanced biomass heating stoves	<ul style="list-style-type: none"> • Reduces energy use for rural heating by 0.8% (mostly gas and LPG), lowers gas imports by 0.3% and total fuel costs by 0.3%. • GHG emissions are reduced by 0.2% (46 kt) in 2030.
Promote solar water heating in commercial sector	<ul style="list-style-type: none"> • Reduces natural gas imports by 0.2% and fuel costs and GHG emissions by 0.1% in 2030. • Electricity generation and power plant investments go up slightly in 2030.
LED lamps for public lighting	<ul style="list-style-type: none"> • Saves almost 27 MEUR from the energy system cost, reduces electricity generation by 0.4% (120 GWh) in 2030, and power plant investments 45 MEUR. • GHG emissions reductions are 9 kt in 2030.
Renewables, appliance & lighting efficiency	<ul style="list-style-type: none"> • Reduces final energy use in buildings by 4.1% and energy system costs by 1.2% (721 MEUR). Electricity generation is reduced by 2.25 TWh in 2030, and power plant investment is reduced by 10% (811 MEUR). • GHG emissions are reduced by 1.8% (352 kt CO₂eq) in 2030.
All Building Retrofits	<ul style="list-style-type: none"> • Reduces Building sector energy use by 3.0%. • Reduces natural gas imports by 2.6%, fuel expenditures by 1.7% and electricity generation by 0.1% in 2030. • Power plant investment costs are reduced by 11 MEUR. • GHG emissions are reduced by 1.7% (322 kt) in 2030.
All RSD & COM Sector Measures	<ul style="list-style-type: none"> • Reduces Building sector energy use by 6.5%. • Reduces natural gas imports by 4.8%, electricity generation by 5.3% and GHG emissions by 3.1% (592 kt) in 2030. • Fuel expenditures are reduced by 3.3% and power plant investment is reduced by 591 MEUR. • Reduces energy system costs by 1.2% (682 MEUR.)

Figure 7 shows the reductions in natural gas imports, CO₂ and GHG emissions for the renewables, appliance & lighting efficiency measures, while Figure 8 shows the reductions in electricity generation, total final energy consumption and power plant investments.

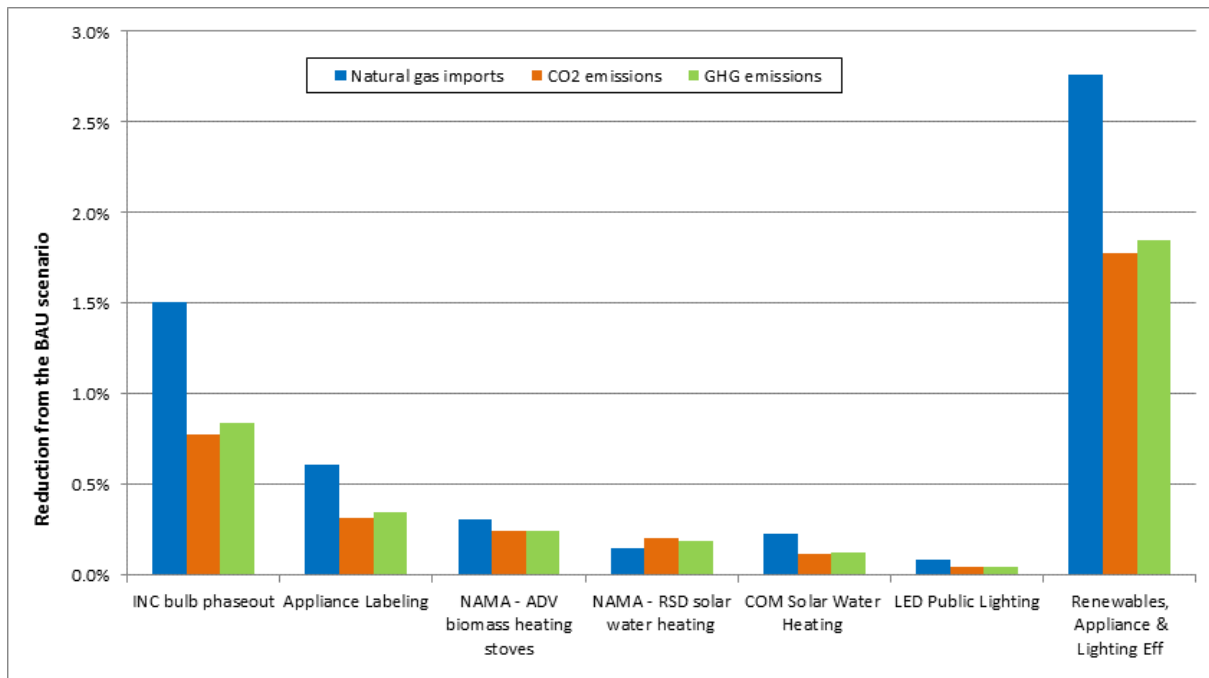


Figure 7: Lighting, Appliance & Renewables Measure Impacts – 1

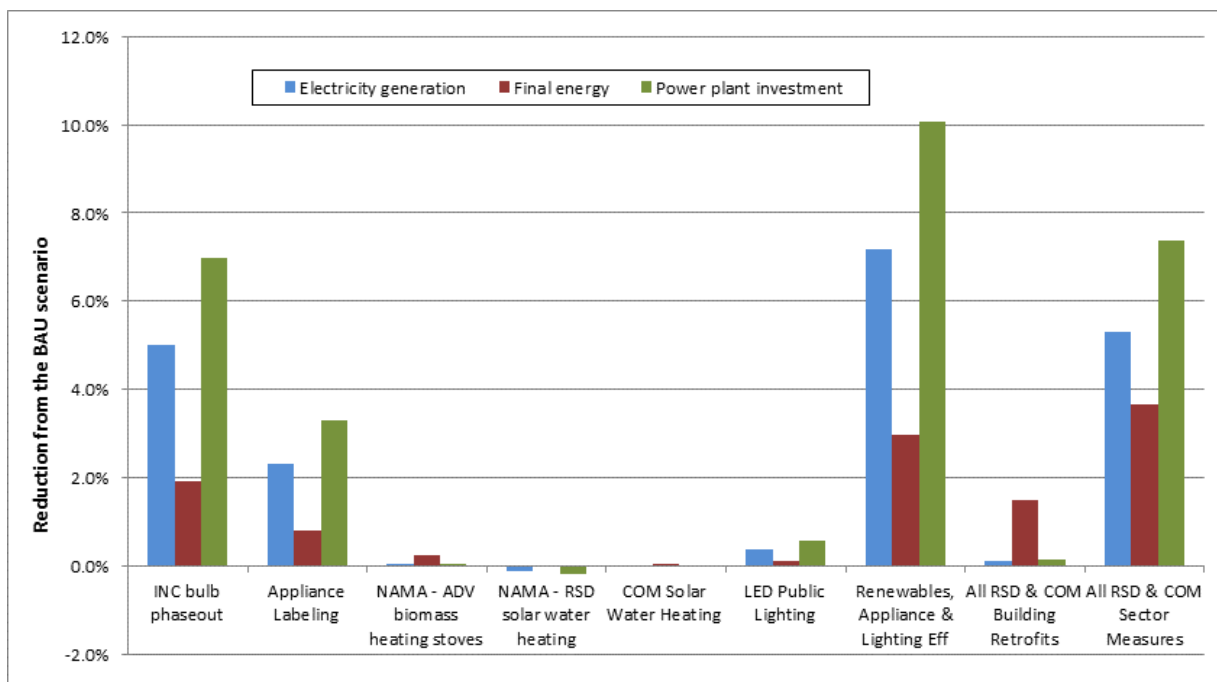


Figure 8: Lighting, Appliance & Renewables Measure Impacts - 2

Figure 9 shows the reductions in natural gas imports, CO₂ and GHG emissions for the commercial and residential building shell measures, while Figure 10 shows the reductions in electricity generation, total final energy consumption and power plant investments for the same measures. These figures also show the impact of the combined Building sector measures, which have about an equal contribution from the building shell measures and the renewables, appliance & lighting efficiency measures.

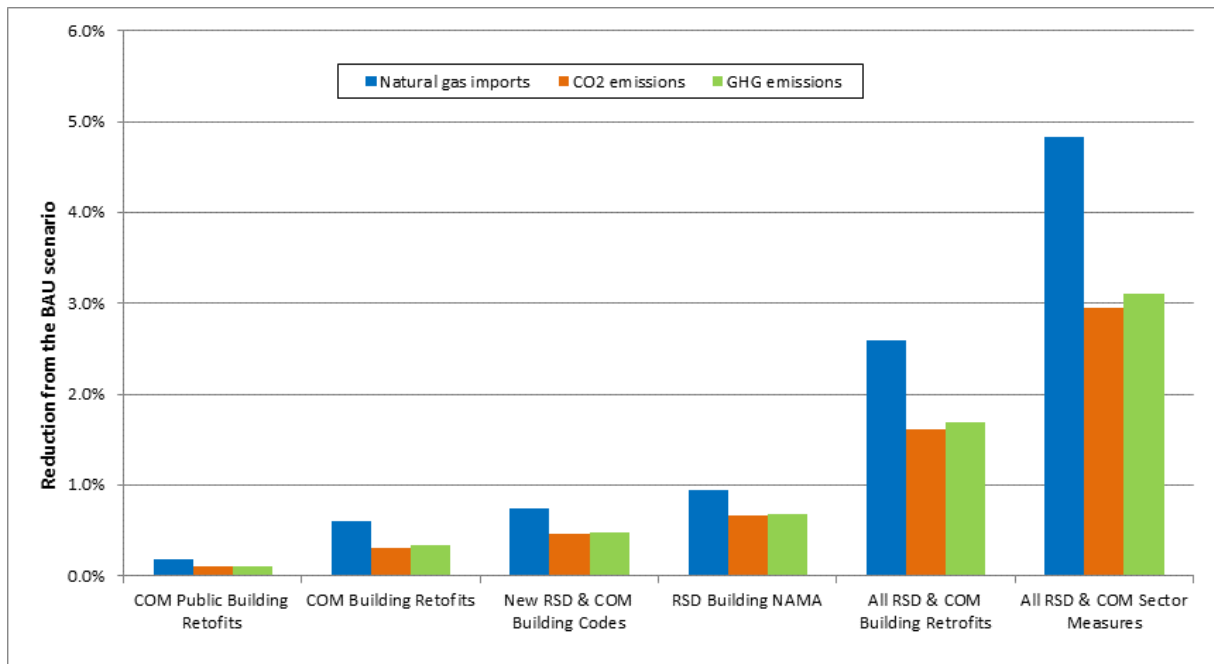


Figure 9: Commercial and Residential Building Shell Measure Impacts – I

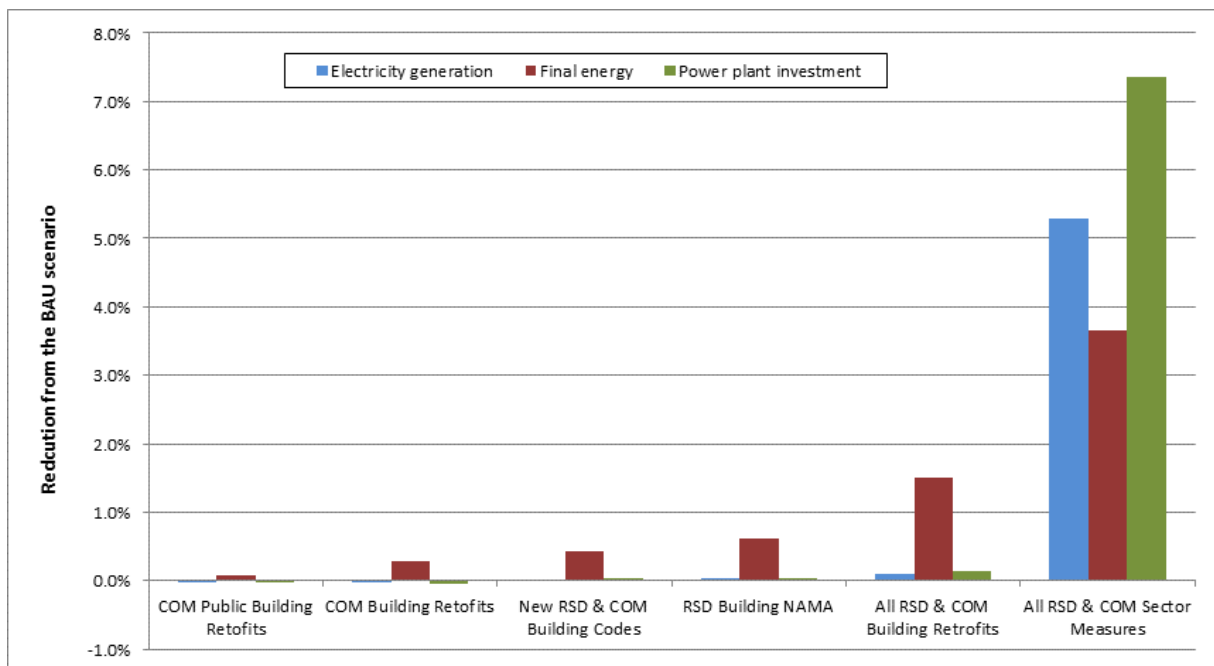


Figure 10: Commercial and Residential Building Shell Measure Impacts - 2

8 INDUSTRY SECTOR ENERGY USE AND GHG EMISSIONS

8.1 Description of Mitigation Measures

The Industrial sector is comprised of six sub-sectors: Chemicals, Food, Iron & Steel, Non-metallic Minerals, Construction and Other. Each subsector requires process heat and mechanical drive services to produce their associated products. Mitigation measures were identified for Chemicals, Food, Iron & Steel and Cement, since these are the most energy intensive industries in Georgia². The measures are based on Georgia-specific industrial plant measures and include various types of process heat efficiency improvements, motor drive efficiency measures, and one cogeneration measure. Impacts of some plant specific and process specific measures have been calculated by Industry expert and provided as inputs to a scenario in the MARKAL-Georgia model. In this way the model can determine the combined effect of these and other measures. There are also two combination runs, and one scenario introducing a Pig iron industry in 2020. These are described in more detail in Table 6.

Table 6: Industry Sector Measures

Name	Description
Chemicals - Efficient burners for ammonia	Based on plant-specific calculations, use of energy efficient natural gas burners in ammonia production at Rustavi Azoti can save 260 TJ. The measure starts in 2022.
Chemicals - Cogeneration in Nitric Acid Production	Based on plant-specific calculations, use the extra process steam from nitric acid production to generate electricity at Rustavi Azoti can produce a new 64 GWh of electricity annually. The measure starts in 2022.
Chemicals industry advanced motive drives	Increase Chemicals industry utilization of advanced and variable speed motors to 50% by 2030. This is general measure for all chemical industry.
Food industry process heat improvement	Increase Food industry utilization of advanced process heat technologies to 30% by 2030. This is general measure for all food industry.
Food industry advanced motive drives	Increase Food industry utilization of advanced and variable speed motors to 50% by 2030. This is general measure for all food industry.
Iron & steel Process heat Improvements	Based on plant-specific calculations, manganese process efficiency improvements can reduce electricity consumption at the manganese plant by 429 TJ per year. The measure is implemented in 2026.
Iron & steel industry Automated Controls	Based on plant-specific calculations, use of automatic controls at the Rustavi Steel mill can reduce natural gas consumption at the Rustavi plant by 2 TJ annually. The measure is implemented in 2020.
Iron & steel industry advanced motive drives	Increase Iron & steel industry utilization of advanced and variable speed motors to 50% by 2030. This is general measure for all Iron and Steel industry.
Cement industry conversion from wet process to dry process	The measures assumes that Kaspi plant of Heidelberg cement Georgia will be converted from wet to dry process and expanded in 2020, and the Rustavi plant will be converted from wet to dry in 2028.

² EC-LEDs Industry Overview Report.

Cement industry utilization of waste heat for clinker drying	Based on plant-specific calculations, the utilization of waste heat for clinker drying can save 5.1 TJ of natural gas at annually Heidelberg Cement Georgia. The measure is implemented in 2020.
Non-metallic Minerals industry advanced motor drives	Increase Non-metallic Minerals industry utilization of advanced and variable speed motors to 50% by 2030. This is general measure of Non-metallic minerals industry
All Industry advanced motor drives	Combines the advanced motor drive measures for the Non-metallic Minerals, Chemicals, Food and Iron & Steel subsectors.
All Industry Efficiency Measures	Combines all the industry measures except the Pig Iron subsector development.
Development of a Pig iron production subsector	The scenario investigates the possibility of starting pig iron production at Rustavi Steel plant. A new Pig Iron industry is started in 2020 with an annual production of 750 kt and a specific consumption of 400 kg of coke per ton of pig iron (8.793PJ annually).

8.2 Mitigation Measures Impact Summary

The results from the Industry sector mitigation measures are organized according to sub-sector, with the Chemicals, Food and Iron & Steel showing smaller impacts than the Non-metallic Minerals industry, which is dominated by cement production. The metrics used to illustrate the impacts of these measures include electricity generation, power plant investment, natural gas imports and industry sector emissions. The results are described below and summarized in Table 7. Appendix A provides a detailed table of results.

The motor drive efficiency measures have a similar impact across all industry subsectors, reducing electricity generation by about 0.1% (26 GWh) in 2030, with a corresponding 0.1% reduction in power plant investment. The energy system cost goes up by about 6 to 8 MEUR in 2030 because of the increased capital expenditures. There are minimal GHG reductions (0.1%) as most of the electricity saved comes from hydropower.

For the Chemicals industry, cogeneration utilizing waste heat from nitric acid production reduced industry sector final energy consumption by 0.4%, electricity generation by 0.2% (66 GWh) and gas imports by 0.1% in 2030. Power plant investment is reduced by 24 MEUR, and the total energy system cost is reduced 24 MEUR. However, GHG emission reductions are only 6 kt in 2030, as most of the electricity savings come from hydropower.

Chemical industry use of more efficient burners for ammonia production results in a 0.2% reduction in natural gas imports and a 0.1% (19 kt) reduction in GHG emissions in 2030. Industry sector final energy use drops by 0.4%, and energy system costs are reduced by 13 MEUR.

Food industry process heat improvement save 0.3% of natural gas imports, reduce industry sector final energy use by 0.7%, and GHG emissions by 0.2%. Total energy system cost is reduced 5 MEUR.

Iron & Steel industry process heat Improvements reduce electricity generation by 0.4% (122 GWh) and natural gas imports by 0.1% in 2030. Power plant investment is reduced by 44 MEUR over the planning horizon, and GHG emissions decrease by 0.1% (12 kt) in 2030.

Iron & Steel industry automated controls has a very small impact, reducing total industry sector final energy use by 0.2 ktoe and GHG emissions by 0.2 kt in 2030.

Cement industry conversion from wet process to dry process has a significant impact, reducing fuel expenditures by 0.8% and reducing total energy system cost by 134 MEUR in 2030. Industry final

energy use is reduced by 6.9% and total final energy by 1.4%. Total GHG emissions go down by 2.4% (458 kt) in 2030.

Cement industry utilization of waste heat for clinker drying has very small effect, as the energy savings is modest. Natural gas consumption is reduced by 0.124 ktoe, and so are natural gas imports. As a result emission reductions are also very small – just 0.37ktons of CO₂eq.

Bundling all the Industry advanced motor drive measures results in a 0.3% reduction in electricity generation, and a 40 MEUR reduction in power plant investment. GHG emissions reductions are 0.1% (10 kt) lower in 2030.

Combining all the Industry sector measures reduces CO₂ emissions by 3% and GHG emissions by 2.8%. Natural gas imports are reduced by 0.7% and electricity generation by 0.9% in 2030. Fuel expenditures are reduced by 1.1% and power plant investment decreases by 107 MEUR.

Development of a Pig Iron production subsector in 2020 leads to 2.9% increase in total final energy consumption and a 4.9% increase in GHG emissions, which are primarily due to CO₂ emissions from coke used in the pig iron production process. Fuel expenditures increase by 2.8% in 2030, and the energy system cost increases by 551 MEUR. Electricity generation is not impacted.

In summary, all the industry measures have a beneficial impact, but the predominant measure is the cement industry wet-to-dry process upgrade, which accounts for 90% of industry sector emission reductions. The addition of a new Pig Iron industry will more than fully offset any reductions, as the CO₂ emission additions are almost twice the reductions from all the sector mitigation measures.

Table 7: Summary Results of Industry Sector Measures

Name	Description
Chemicals - Efficient burners for ammonia	<ul style="list-style-type: none"> Reduces industry sector final energy consumption by 0.4% and gas imports by 0.1% in 2030. Reduces electricity generation by 0.2% (66 GWh), and power plant investment by 24 MEUR. Energy system cost is reduced 13 MEUR. Reduces GHG emission by only 6 kt in 2030, as most of the electricity savings come from hydropower.
Chemicals - Cogeneration in Nitric Acid Production	<ul style="list-style-type: none"> Reduces natural gas imports by 0.2% and industry sector final energy use by 0.4%. Reduces GHG emissions by 0.1% (19 kt) reduction in 2030. Energy system costs are reduced by 24 MEUR.
Chemicals - Advanced motive drives	<ul style="list-style-type: none"> Reduces electricity generation by about 0.1% in 2030, and power plant investment is reduced by 0.1%. Increases energy system cost by 7 MEUR in 2030. GHG reductions are minimal.
Food - Process heat improvement	<ul style="list-style-type: none"> Reduces natural gas imports by 0.3% and industry sector final energy use by 0.7%. Reduces GHG emissions by 0.2%. Decreases energy system cost by 5 MEUR.
Food - Advanced motive drives	<ul style="list-style-type: none"> Reduces electricity generation by about 0.1% in 2030, and power plant investment is reduced by 0.1%. Increases energy system cost by 6 MEUR in 2030. GHG reductions are minimal.

Iron & steel - process heat improvements	<ul style="list-style-type: none"> • Reduces electricity generation by 0.4% (122 GWh) and natural gas imports by 0.1% in 2030. • Reduces power plant investment by 44 MEUR. • Decreases GHG emissions by 0.1% (12 kt) in 2030.
Iron & steel - Automated controls	<ul style="list-style-type: none"> • Reduces industry sector final energy use by 0.2 ktoe. • Reduces GHG emissions by 0.2 kt in 2030.
Iron & steel - Advanced motive drives	<ul style="list-style-type: none"> • Reduces electricity generation by about 0.1% in 2030, and power plant investment is reduced by 0.1%. • Increases energy system cost by 7 MEUR in 2030. • GHG reductions are minimal.
Cement - Conversion from wet process to dry process	<ul style="list-style-type: none"> • Reduces industry final energy use by 6.9% and fuel expenditures by 0.8% in 2030. • Reduces total energy system cost by 134 MEUR. • Reduces GHG emissions by 2.4% (458 kt) in 2030.
Cement - Utilization of waste heat for clinker drying	<ul style="list-style-type: none"> • Reduces natural gas imports and industry sector final energy use by 0.003% • Reduces GHG emissions by 0.002% (0.365 kt) in 2030.
Cement - Advanced motor drives	<ul style="list-style-type: none"> • Reduces electricity generation by about 0.1% in 2030, and power plant investment is reduced by 0.1%. • Increases energy system cost by 8 MEUR. • GHG reductions are minimal.
All Industry - Advanced motor drives	<ul style="list-style-type: none"> • Reduces electricity generation by about 0.3% in 2030, and power plant investment is reduced by 0.4%. • Increases energy system cost by 26 MEUR. • GHG reductions are 0.1%.
All Industry - Efficiency measures	<ul style="list-style-type: none"> • Reduces natural gas imports by 0.7% and electricity generation by 0.9% in 2030. • Reduces fuel expenditures by 1.1% and power plant investment by 107 MEUR. • Reduces CO₂ emissions by 3% and GHG emissions by 2.8%.
Pig Iron – Development of new subsector	<ul style="list-style-type: none"> • Increases total final energy consumption by 2.9% for the coke used in the pig iron production process. • Fuel expenditures increase 2.8% in 2030 and energy system cost increases by 809 MEUR. • Increases GHG emissions by 4.9%. • Reduces energy system cost by 174 MEUR.

Figure 11 shows the reductions in natural gas imports, CO₂ and GHG emissions for the Chemicals, Food and Iron & Steel industry subsector measures, while Figure 12 shows the reductions in electricity generation, total final energy consumption and power plant investments for the same measures.

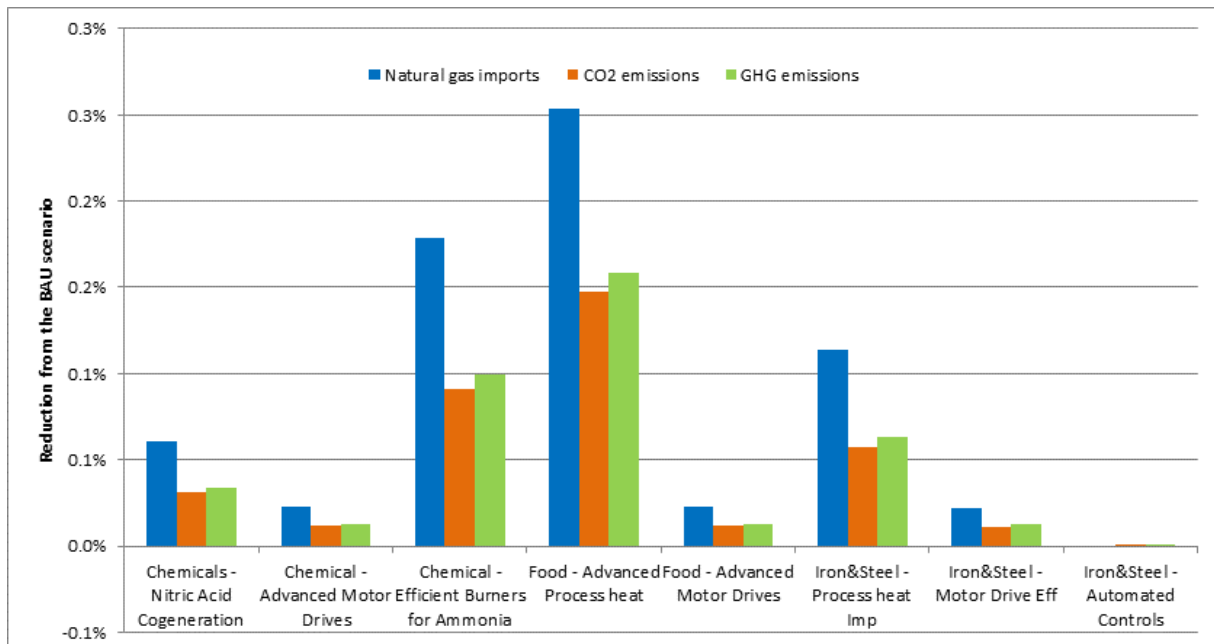


Figure 11: Chemicals, Food and Iron & Steel Industry Measure Impacts – 1

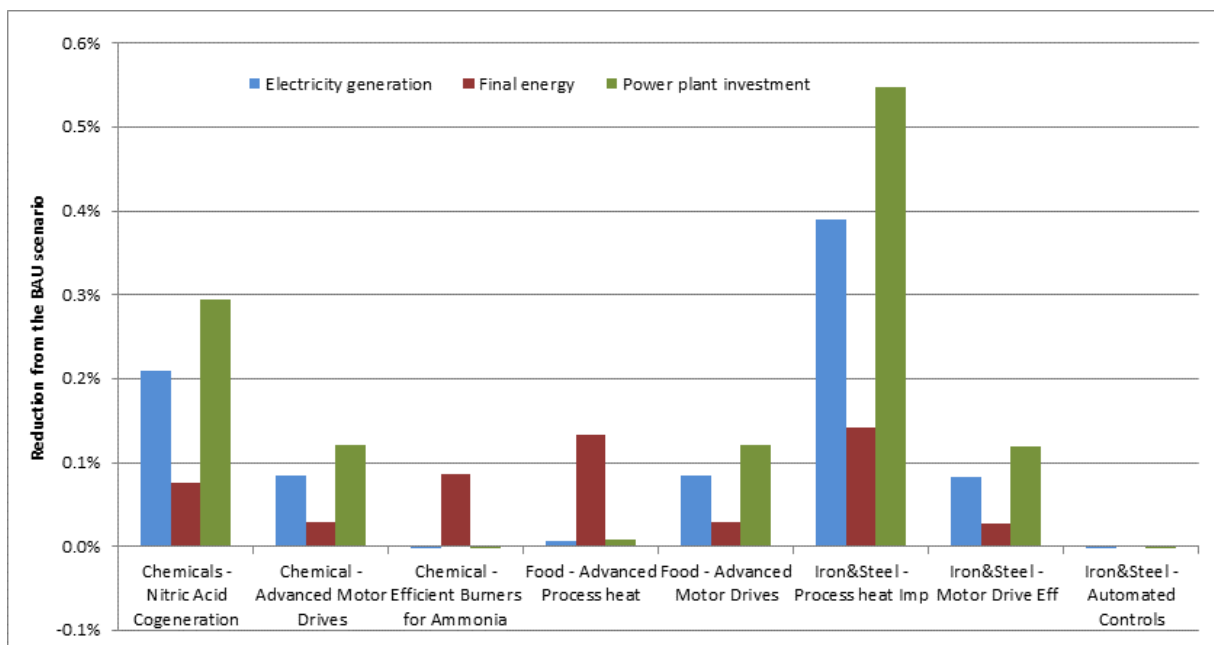


Figure 12: Chemicals, Food and Iron & Steel Industry Measure Impacts – 2

Figure 13 shows the reductions in natural gas imports, CO₂ and GHG emissions for the Non-metallic minerals (cement) industry measures, while

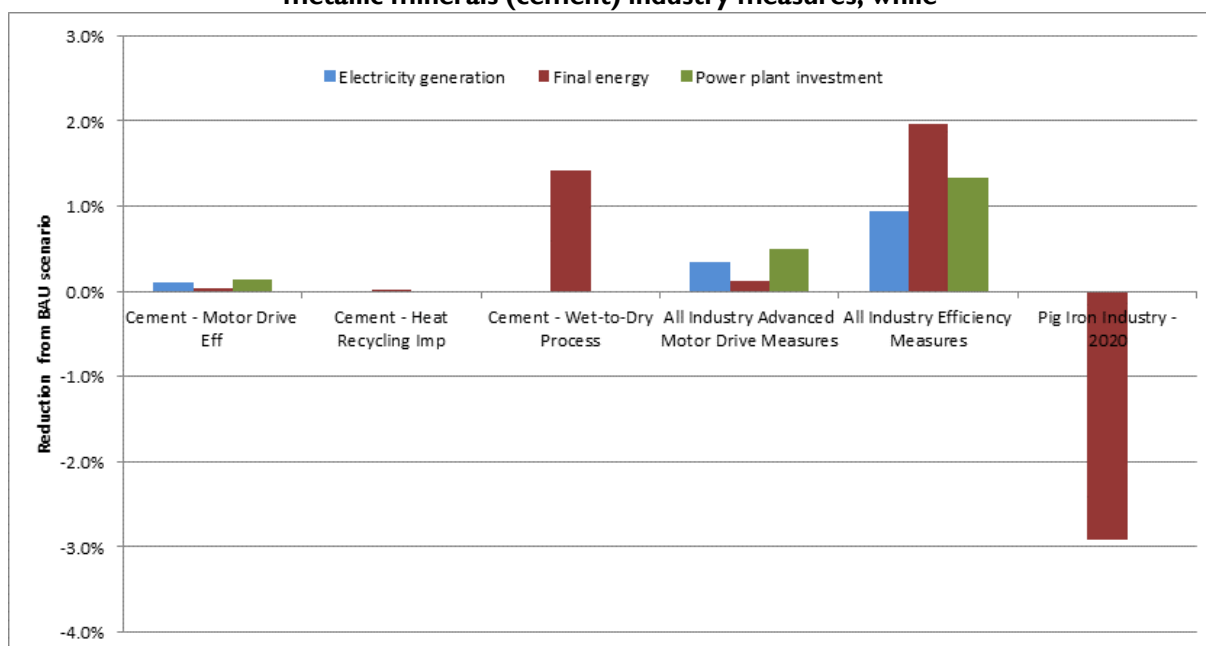


Figure 14 shows the reductions in electricity generation, total final energy consumption and power plant investments for the same industry subsectors. The impacts are very small for the first two measures. These figures also show the impact of the combined advanced motor drive measures, the combination of all Industry sector reductions measures and the addition of a Pig Iron industry.

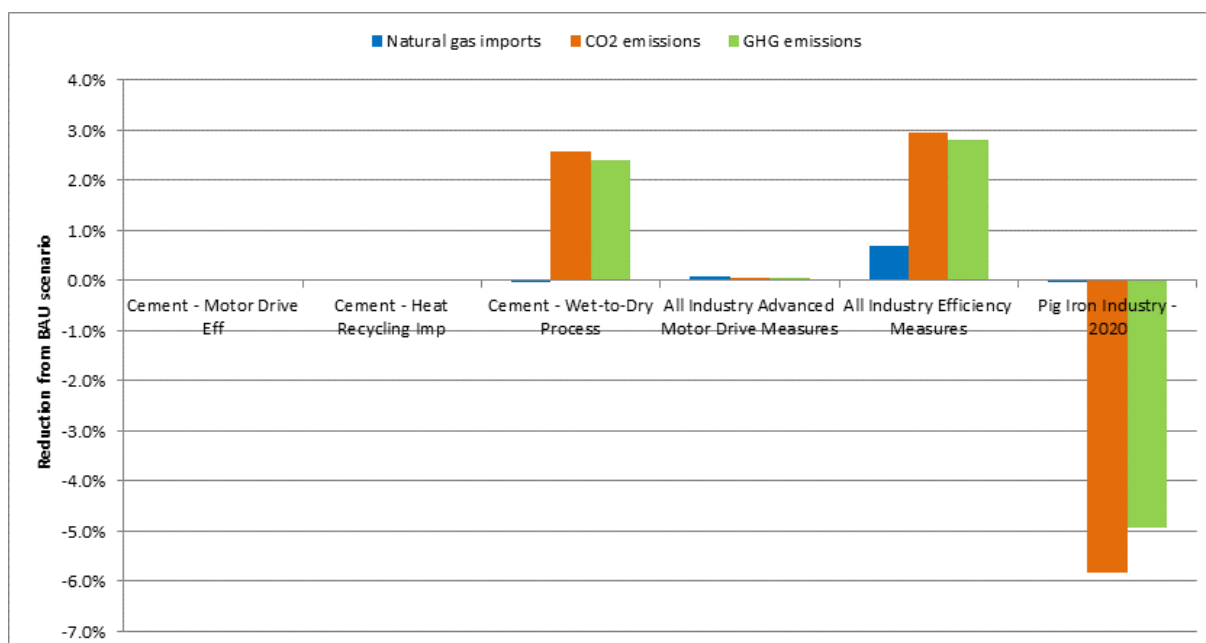


Figure 13: Cement, Combined and Pig Iron Industry Measure Impacts - I

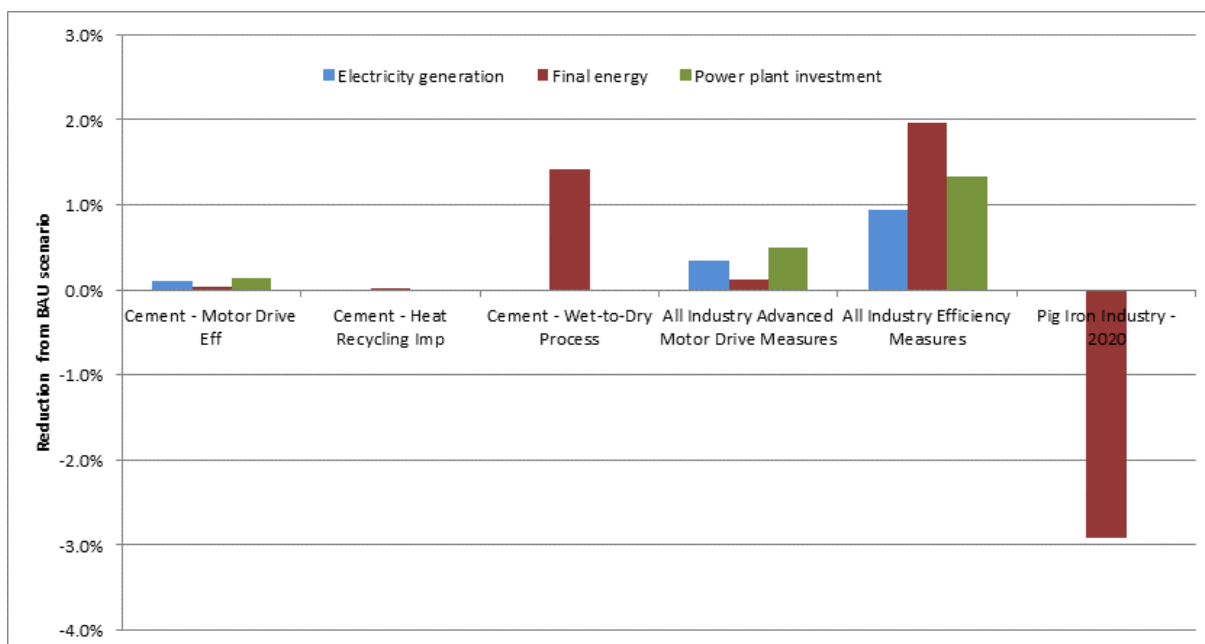


Figure 14: Cement, Combined and Pig Iron Industry Measure Impacts - 2

9 TRANSPORTATION SECTOR ENERGY USE AND GHG EMISSIONS

9.1 Description of Mitigation Measures

The transportation sector is sub-divided into passenger and freight transport modes. The mitigation measures fall into two categories: i) improving vehicle efficiency and switching to cleaner fuels, and ii) shifting transport activity from a less efficient to a more efficient mode (e.g. car to bus). Most measures deal with passenger transport, both urban and inter-city, and a few deal with freight transport

Table 8: Transportation Sector Measures

Description	Details
Promote Biofuels: 6% by 2030	A biofuels blending requirement is implemented in 2020 that grows to 6% of road transport fuels by 2030.
Improve LDV stock and fuel standards	Mandatory vehicle inspections and higher taxes on import of older LDVs are introduced so that new and better vehicles penetrate the market, resulting in a 5% improvement of new LDV efficiency by 2030.
Improve all road vehicle stock and mandatory inspections	Mandatory vehicle inspection and improved fuel standards for all road vehicles (LDVs, light and heavy trucks, buses and mini-buses) are introduced so that vehicles are better maintained, resulting in a 5% improvement of new vehicle efficiency by 2030.

Promote hybrid and electric vehicles	Eliminating the tax on import of electric and hybrid vehicles is assumed to lead to a 5% market share for hybrids and 1% market share for electric vehicles by 2030.
Promote urban transport	Municipal public transport is improved and expanded to attract more ridership, resulting in a shift of 1.5% of total passenger transport demand to Bus and away from LDV and Minibus by 2020 and 5% by 2030. This represents the impact of existing Sustainable Energy Action Plans (SEAPs) by 2020 and the possibility of expanding the measures nationwide to other urban areas by 2030.
Promote CNG buses	Promotion of CNG buses leads to up to 53% of existing buses being shifted to CNG or hybrid by 2030.
Taxi regulations	Increasing regulations of taxis raise the cost of using taxis, which now hinders the development of rail and bus, and decreases LDV transport demand by 3% in 2030.
Implement public parking systems	Increase cost for inner-city parking shifts 0.11% of LDV transport demand to BUS and Minibus demand by 2020 and 0.5% by 2030. This represents the impact of existing Sustainable Energy Action Plans (SEAPs) by 2020 and the possibility of expanding the measures nationwide to other urban areas by 2030.
Promote walking and cycling	Develop and maintain cycling & walking infrastructure that reduces LDV transport demand by 1.5% in 2020 and 3% by 2030. This represents the impact of existing Sustainable Energy Action Plans (SEAPs) by 2020 and the possibility of expanding the measures nationwide to other urban areas by 2030.
Promote two wheelers	Promoting 2-wheelers in cities with hills shifts 0.05% of total LDV transport demand to 2-wheelers by 2020 and 2.7% by 2030. This represents the impact of existing Sustainable Energy Action Plans (SEAPs) by 2020 and the possibility of expanding the measures nationwide to other urban areas by 2030.
Improve Intercity passenger rail	Assuming a new rail link to Turkey, as well as improvement of rail passenger service and infrastructure, so that 5% of all road passenger transport is shifted from LDVs and Buses to Rail using an 80%-20% split.
Improve intercity bus transport	Improved service and routes leads to a 20% increase in the passenger transport share for buses and minibus reducing LDV transport demand by 2030.
Promote freight transport shift from heavy truck to rail	New railway to Turkey, improved rail infrastructure and coherent freight transport policy will shift the freight from Heavy trucks to Rail such that Rail accounts for 50% of all freight transport by 2030.
All non-mode-shift measures	Combines all transport non-mode shift measures except the biofuels target.
All mode shift measures	Combines all transport mode-shift measures.
All transport sector measures	Combines all transport sector measures except the biofuels target.

9.2 Mitigation Measures Impact Summary

The results from the Transportation Sector mitigation measures used to illustrate the impacts of the measures includes final energy use, natural gas imports, electricity generation, power plant investments and transport sector emissions. The results are described below and summarized in Table 9. Appendix A provides a detailed table of results.

Promoting biofuels through a blending target of 6% in 2030 reduces transport sector CO₂ emissions by 6.1% and overall GHG emissions by 2.2% (409 kt) in 2030. Fuel expenditures increase by 0.2% (5 MEUR) in 2030, and energy system cost increases by 32 MEUR. Import of oil products is reduced by 0.2% (12 ktoe) in 2030.

Improving the LDV stock with better fuel standards, mandatory inspections and other measures, results in a 1.0% reduction of transport fuel use, a 0.6% reduction in fuel costs and a 0.5% reduction in natural gas imports in 2030. Energy system costs decrease by 63 MEUR and GHG emissions are reduced by 0.4% (83 kt) in 2030.

Improving the efficiency of the entire road vehicle stock, through better fuel standards, mandatory inspections and other measures, results in a 1.7% reduction of transport fuel use, a 1.1% reduction in fuel costs and a 0.6% reduction in natural gas imports in 2030. Energy system costs decrease by 104 MEUR and GHG emissions are reduced by 0.7% (138 kt) in 2030.

Promoting hybrid and electric vehicles reduces transport energy use by 3.4%, natural gas imports by 1.8%, and increases electricity generation by 1.1% (largely from hydropower) in 2030. Energy system costs increase by 172 MEUR and power plant investments increase 124 MEU. GHG emissions decrease by 1.7% (329 kt) in 2030.

Promoting improved urban public transport systems reduces energy system costs by 136 MEUR and reduces GHG emissions by 0.2% (40 kt) in 2030. Natural gas imports and fuel expenditures drop by 0.3%. Electricity generation is not impacted.

Promoting CNG buses results in a 0.4% increase in natural gas imports, but a 0.2% decrease in fuel expenditures. Energy system cost decreases by 7 MEUR, and although transport sector emissions decrease by 0.108 kt, the total GHG emissions increase by 0.1% (10 kt) in 2030, due to an increase in fugitive methane emissions from gas use. The effect of this emission will be stronger when combined with the measure on reduction of natural gas losses in power sector.

Implementing new taxi regulations to lower LDV use reduces transport final energy by 1.5% and total fuel expenditures by 1.1% in 2030. Natural gas imports drop by 0.5%, and electricity generation is not impacted. GHG emissions decrease by 0.7% (124 kt) in 2030. Energy system costs decrease by 1.2 billion EUR (BEUR) due to reduced vehicle purchases.

Implement public parking systems to lower LDV use reduces transport final energy by 0.2% and total fuel expenditures by 0.1% in 2030. Natural gas imports drop by 0.1%, and electricity generation is not impacted. GHG emissions decrease by 0.1% (16 kt) in 2030. Energy system costs decrease by 50 MEUR.

Promoting walking and cycling to lower LDV use reduces transport final energy by 1.5% and total fuel expenditures by 1.1% in 2030. Natural gas imports drop by 0.5%, and electricity generation is not impacted. GHG emissions decrease by 0.6% (122 kt) in 2030. Energy system costs decrease by 376 MEUR due to reduced vehicle purchases.

Promote two wheelers to lower LDV use reduces transport final energy by 0.7% and total fuel expenditures by 0.3% in 2030. Natural gas imports drop by 0.5%, and electricity generation is not impacted. GHG emissions decrease by 0.3% (59 kt) in 2030. Energy system costs decrease by 106 MEUR.

Improving intercity passenger rail through the new link to Turkey and improved service reduces transport final energy use by 1.6% and total fuel expenditures by 1.7% in 2030. Natural gas imports drop by 0.6%, and electricity generation increases by 1.1% (340 GWh) in 2030. Power plant

investment increases by 124 MEUR. Total imports are reduced by 0.9%, and GHG emissions decrease by 0.9% (178 kt) in 2030. Energy system costs decrease by 474 MEUR.

Promoting intercity bus transport through improved service reduces transport final energy use by 0.8% and total fuel expenditures by 0.5% in 2030. Natural gas imports drop by 0.3%, and electricity generation is not impacted. GHG emissions decrease by 0.3% (62 kt) in 2030. Energy system costs decrease by 143 MEUR.

Promoting a shift in freight transport from Heavy truck to Rail freight reduces transport final energy use by 8.2% and total fuel expenditures by 7.1% in 2030. Natural gas imports drop by 1.0%, and electricity generation increases 0.6% in 2030. GHG emissions decrease by 3.8% (715 kt) in 2030. Energy system costs decrease by 2.29 BEUR, but the cost of rail infrastructure improvements are not included.

All non-passenger-mode-shift Transport sector measures (which include the truck-rail-freight mode shift) reduce transport final energy use by 10.8% and total fuel expenditures by 9.8% in 2030. Natural gas imports drop by 1.3%, and total imports drop by 5.0%. Electricity generation is increased 1.4% in 2030, and power plant investment increases 156 MEUR. GHG emissions decrease by 5.1% (964 kt) in 2030. Energy system costs decrease by 2.21 BEUR.

Combining all the passenger transport mode shift measures reduces transport final energy use by 6.8% and total fuel expenditures by 9.8% in 2030. Natural gas imports drop by 2.7%, and total imports drop by 5.1%. Electricity generation is increased 1.1% in 2030, and power plant investment increases 123 MEUR. GHG emissions decrease by 3.2% (603 kt) in 2030. Energy system costs decrease by 2.1 BEUR, but the cost of rail infrastructure improvements are not included.

Combining all the Transport sector measures (not including biofuels measure) reduces transport final energy use by 18.5% and total fuel expenditures by 14.9% in 2030. Natural gas imports drop by 5.2%, and total imports drop by 8.6%. Electricity generation is increased 2.5% in 2030, and power plant investment increases 279 MEUR. GHG emissions decrease by 8.7% (1656 kt) in 2030. Energy system costs decrease by 4.33 BEUR, but the cost of rail infrastructure improvements are not included.

Table 9: Summary Results of Transportation Sector Measures

Description	Details
Promote Biofuels: 6% by 2030	<ul style="list-style-type: none"> Reduces GHG emissions by 2.2% (409 kt) and import of oil products 0.2% (12 ktoe) in 2030. Increases fuel expenditures by 0.2% in 2030 Increases energy system cost 32 MEUR.
Improve LDV stock and fuel standards	<ul style="list-style-type: none"> Reduces transport fuel use by 1.0%, fuel costs by 0.6% and natural gas imports by 0.5% in 2030. Decreases energy system costs by 63 MEUR and Reduces GHG emissions by 0.4% (83 kt) in 2030.
Improve road vehicle stock and mandatory inspections	<ul style="list-style-type: none"> Reduces transport fuel use by 1.7% reduction, fuel costs by 1.1% and natural gas imports by 0.6% in 2030. Decreases energy system costs by 104 MEUR Reduces GHG emissions by 0.7% (138 kt) in 2030.
Promote hybrid and electric vehicles	<ul style="list-style-type: none"> Reduces transport fuel use by 3.4% and natural gas imports by 1.8% in 2030. Increases electricity generation by 1.1% (largely from hydropower) in 2030, and increases power plant investment 124 MEUR. Increases energy system costs by 172 MEUR. Decreases GHG emissions by 1.7% (329 kt) in 2030.
Promote Urban Transport	<ul style="list-style-type: none"> Reduces energy system costs by 136 MEUR.

	<ul style="list-style-type: none"> • Reduces natural gas imports and fuel expenditures by 0.3% in 2030. • Reduces GHG emissions by 0.2% (40 kt) in 2030.
Promote CNG Buses	<ul style="list-style-type: none"> • Increases natural gas imports by 0.4%, but decreases fuel expenditures by 0.2% in 2030. • Decreases energy system cost by 7 MEUR. • increases GHG emissions by 0.1% (10 kt) in 2030.
Taxi regulations	<ul style="list-style-type: none"> • Reduces transport final energy use by 1.5%, total fuel expenditures by 1.1%, and natural gas imports by 0.5% in 2030. • Decreases GHG emissions by 0.7% (124 kt) in 2030. • Decreases energy system costs by 1.2 BEUR due to reduced vehicle purchases.
Implement public parking systems	<ul style="list-style-type: none"> • Reduces transport final energy by 0.2%, total fuel expenditures by 0.1% and natural gas imports by 0.1% in 2030. • Decreases GHG emissions by 0.1% (16 kt) in 2030. • Decreases energy system costs by 50 MEUR.
Promote Walking and Cycling	<ul style="list-style-type: none"> • Reduces transport final energy by 1.5%, total fuel expenditures by 1.1%, and natural gas imports by 0.5% in 2030. • Decreases GHG emissions by 0.6% (122 kt) in 2030. • Decreases energy system costs by 376 MEUR.
Promote two wheelers	<ul style="list-style-type: none"> • Reduces transport final energy by 0.7%, total fuel expenditures by 0.3% and natural gas imports by 0.5% in 2030. • Decreases GHG emissions by 0.3% (59 kt) in 2030. • Decreases energy system costs by 106 MEUR.
Improve Intercity passenger rail	<ul style="list-style-type: none"> • Reduces transport final energy use by 1.6%, total fuel expenditures by 1.7% and natural gas imports by 0.6% in 2030. • Increases electricity generation by 1.1% (340 GWh) in 2030, and increases power plant investment by 124 MEUR. • Reduces total imports by 0.9%, and GHG emissions by 0.9% (178 kt) in 2030. • Decreases energy system costs by 474 MEUR.
Improve intercity bus transport	<ul style="list-style-type: none"> • Reduces transport final energy use by 0.8%, total fuel expenditures by 0.5%, and natural gas imports by 0.3% in 2030. • Decreases GHG emissions by 0.3% (62 kt) in 2030. • Decreases energy system costs by 143 MEUR.
Promote freight transport shift from Heavy truck to Rail	<ul style="list-style-type: none"> • Reduces transport final energy use by 8.2%, total fuel expenditures by 7.1% and natural gas imports by 1.0% in 2030. • Increases electricity generation 0.6% in 2030. • Decreases GHG emissions by 3.8% (715 kt) in 2030. • Decreases energy system costs by 2.29 BEUR, but rail infrastructure costs are not included.
All Non-passenger-Mode-Shift TRN Measures	<ul style="list-style-type: none"> • Reduces transport final energy use by 10.8%, total fuel expenditures by 9.8% and natural gas imports by 1.3% in 2030. • Decreases total imports by 5.0%. • Increases electricity generation by 1.4% in 2030, and increases power plant investment by 156 MEUR. • Decreases GHG emissions by 5.1% (964 kt) in 2030. • Decreases energy system costs by 2.21 BEUR.
Combined TRN passenger Mode Shifts	<ul style="list-style-type: none"> • Reduces transport final energy use by 6.8%, total fuel expenditures by 9.8% and natural gas imports by 2.7% in 2030. • Decreases total imports by 5.1%. • Increases electricity generation by 1.1% in 2030, and power plant investment by 123 MEUR. • Decreases GHG emissions by 3.2% (603 kt) in 2030. • Decreases energy system costs by 2.1 BEUR, but rail infrastructure costs are not included.

All TRN Measures and Mode Shifts	<ul style="list-style-type: none"> • Reduces transport final energy use by 18.5%, total fuel expenditures by 14.9%, and natural gas imports by 5.2% in 2030. • Decreases total imports by 8.6%. • Increases electricity generation by 2.5% in 2030, and power plant investment by 279 MEUR. • Decreases GHG emissions by 8.7% (1656 kt) in 2030. • Decreases Energy system costs by 4.34 BEUR, but rail infrastructure costs are not included.
----------------------------------	---

Figure 15 shows the reductions in natural gas imports, CO₂ and GHG emissions for the first half of the transportation sector measures, while Figure 16 shows the reductions in electricity generation, total final energy consumption and power plant investments for the same measures. Note the increases (negative reductions) for electricity generation and power plant investment in the hybrid and electric vehicle measure.

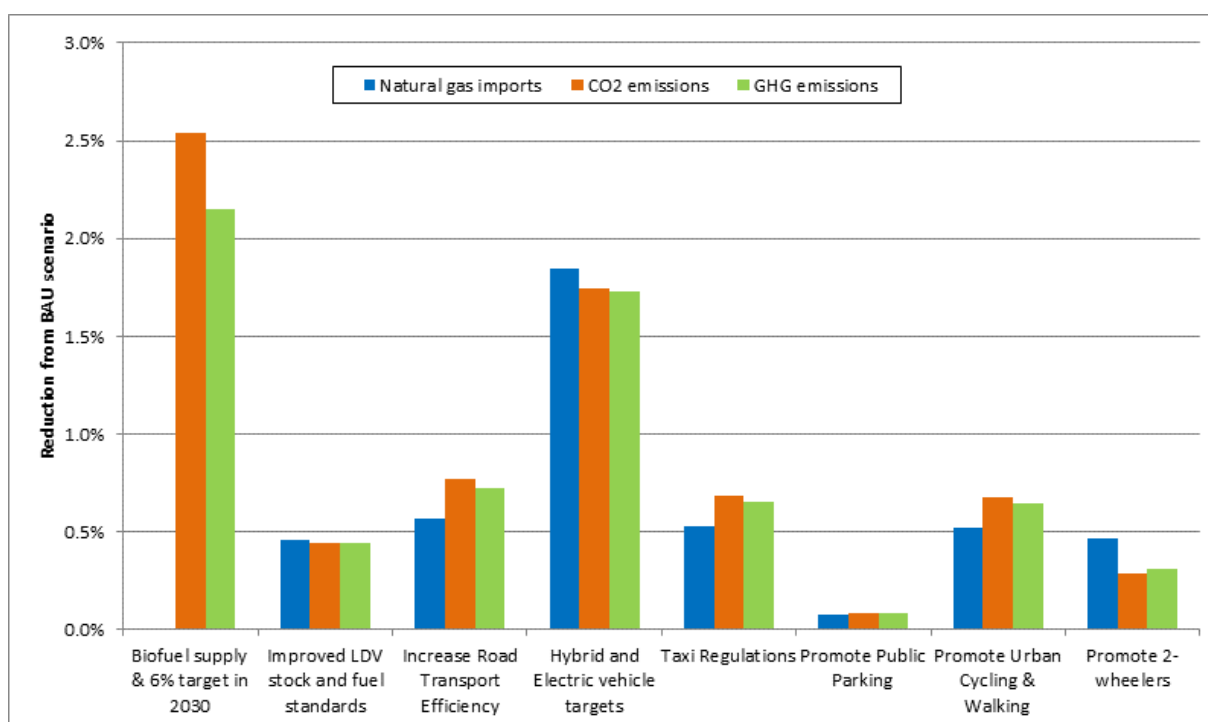


Figure 15: Transport Sector Measure Impacts - I

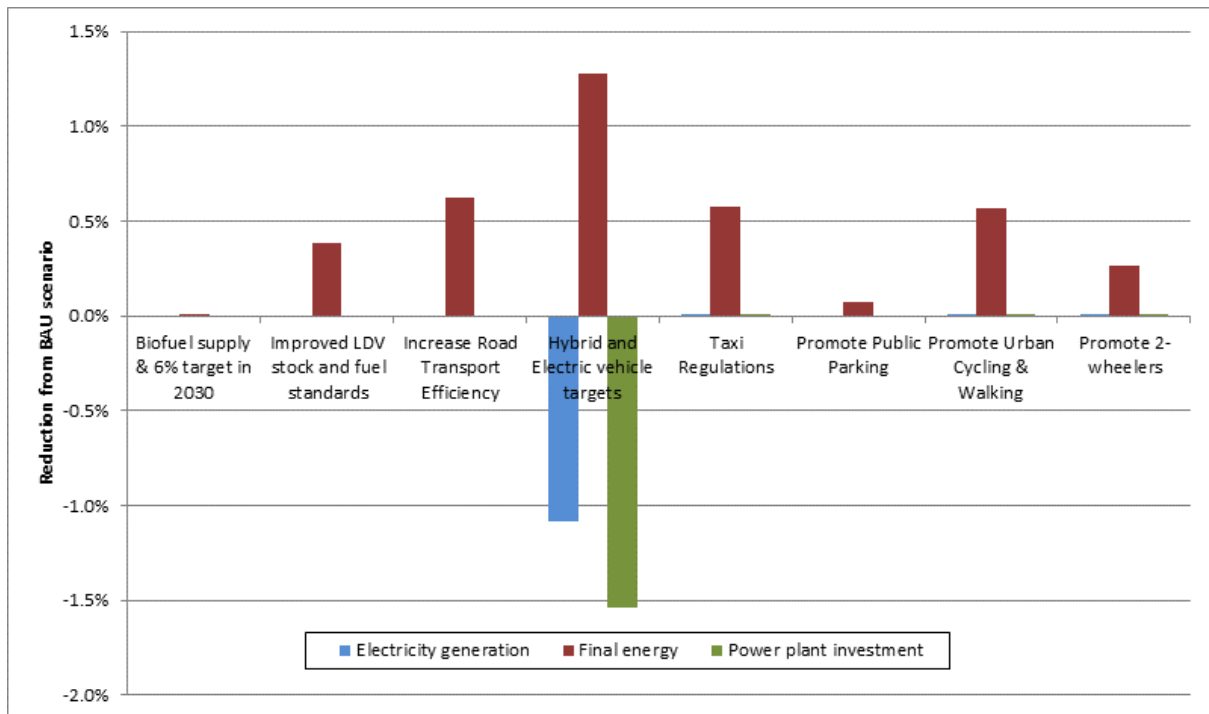


Figure 16: Transport Sector Measure Impacts - 2

Figure 17 shows the reductions in natural gas imports, CO₂ and GHG emissions for the second set of transport sector measures, while Figure 18 shows the reductions in electricity generation, total final energy consumption and power plant investments for the same measures. These figures also show the impact of the combined non-mode-shift measures, the combination of all mode-shift measures and the combination of all transport sector measures. Many of the mode shift measures produce increases in electricity generation and power plant investment.

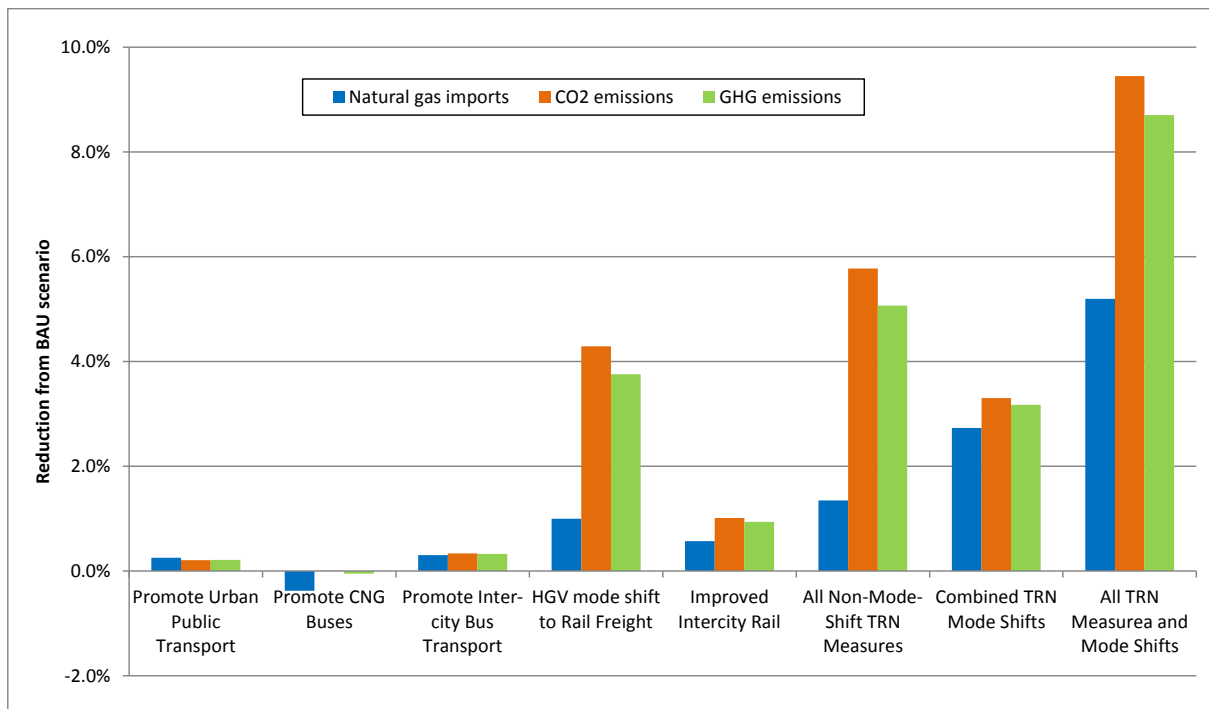


Figure 17: Transport Sector Measure Impacts - 3

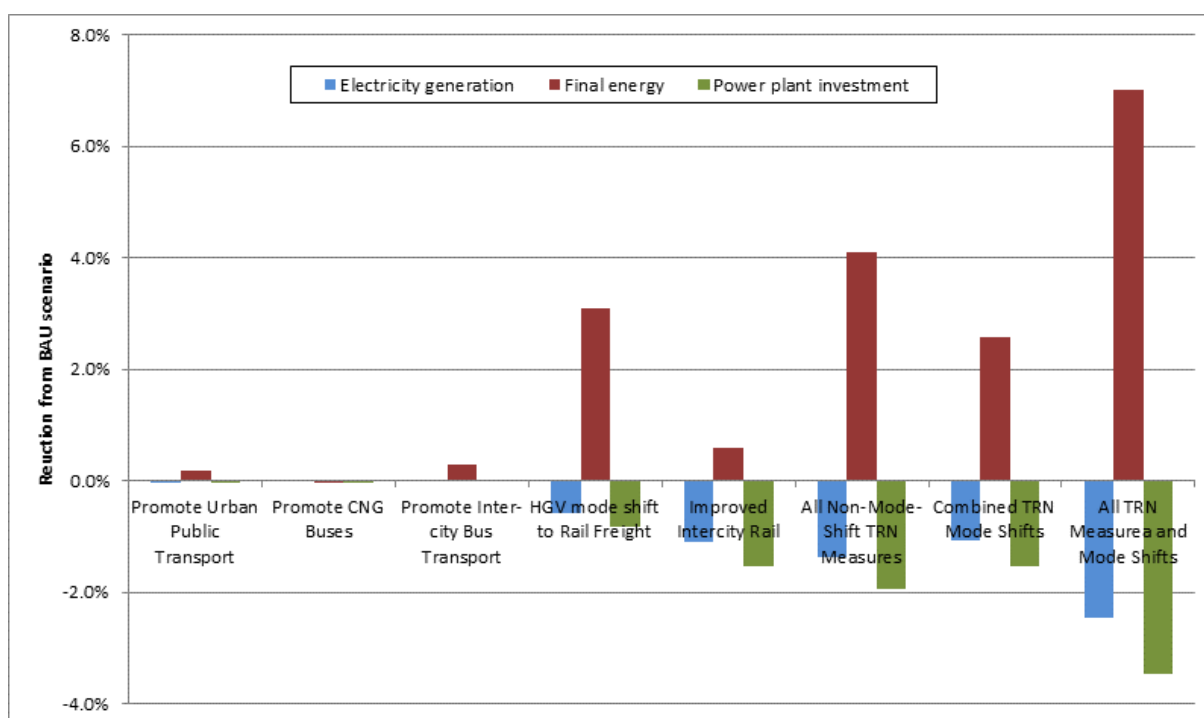


Figure 18: Transport Sector Measure Impacts - 4

10 ALL SECTORS COMBINED

Many of the individual LEDS measures have some overlapping or counteracting impacts that are not necessarily additive, and so the MARKAL-Georgia model was used to ensure that the combined impacts of the measures is properly integrated. This section looks at the combination scenarios for each sector and the full set of integrated measures for Georgia.

Table 10: Summary of Results for Sectoral and All LEDS Measures

Description	Details
All supply and power sector measures	<ul style="list-style-type: none"> Reduce natural gas imports by 11% and lowers GHG emissions by 12.5%. Reduces fuel costs by 104 MEUR in 2030, and power plant investment increases by 573 MEUR. Reduces energy system costs by 13 MEUR.
All Buildings (Commercial and Residential) Sector Measures	<ul style="list-style-type: none"> Reduces natural gas imports by 4.8%, electricity generation by 5.3% and GHG emissions by 3.1% (592 kt) in 2030. Fuel expenditures are reduced by 3.3% and power plant investment is reduced by 591 MEUR. Reduces energy system costs by 682 MEUR.
All Industry Sector Measures	<ul style="list-style-type: none"> Reduces natural gas imports by 0.7% and electricity generation by 0.9% in 2030. Reduces fuel expenditures by 1.1% and power plant investment by 107 MEUR. Reduces CO2 emissions by 3% and GHG emissions by 2.8%. Reduces energy system costs by 174 MEUR.
All Transport Sector Measures and Mode Shifts	<ul style="list-style-type: none"> Reduces transport final energy use by 18.5%, total fuel expenditures by 14.9%, and natural gas imports by 5.2% in 2030. Decreases total imports by 8.6%. Increases electricity generation by 2.5% in 2030, and power plant

	investment by 279 MEUR. <ul style="list-style-type: none"> Decreases GHG emissions by 8.7% (1656 kt) in 2030. Decreases energy system costs by 4.34 BEUR, but rail infrastructure costs are not included.
All LEDS Measures	<ul style="list-style-type: none"> Reduces total final energy use by 8.8%, total fuel expenditures by 14.5%, and natural gas imports by 17.7% in 2030. Decreases total imports by 13.8%. Decreases electricity generation by 8.2% in 2030, and power plant investment by 2.57 BEUR. Decreases GHG emissions by 21.1% (4027 kt) in 2030. Decreases energy system costs by 3.0 BEUR, but rail infrastructure costs are not included.

Figure 19 shows the reductions in natural gas imports, CO₂ and GHG emissions for the set of all combined sector measures, while Figure 20 shows the changes in electricity generation, total final energy consumption and power plant investments for the same measures. Note that the power sector and transport sectors have increases in power plant investments, and the transport sector has an increase in electricity generation. However, the combination of all measures has reductions in all three metrics.

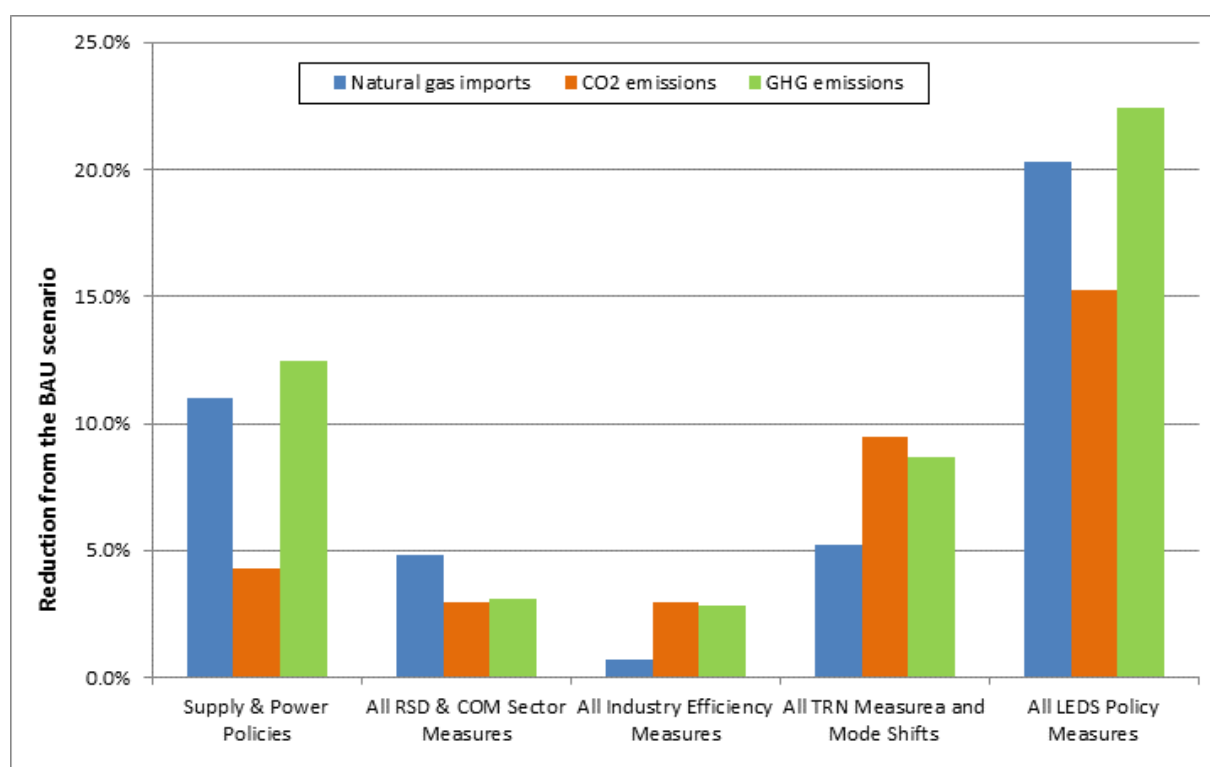


Figure 19: Sectoral and Combined LEDS Measure Impacts - I

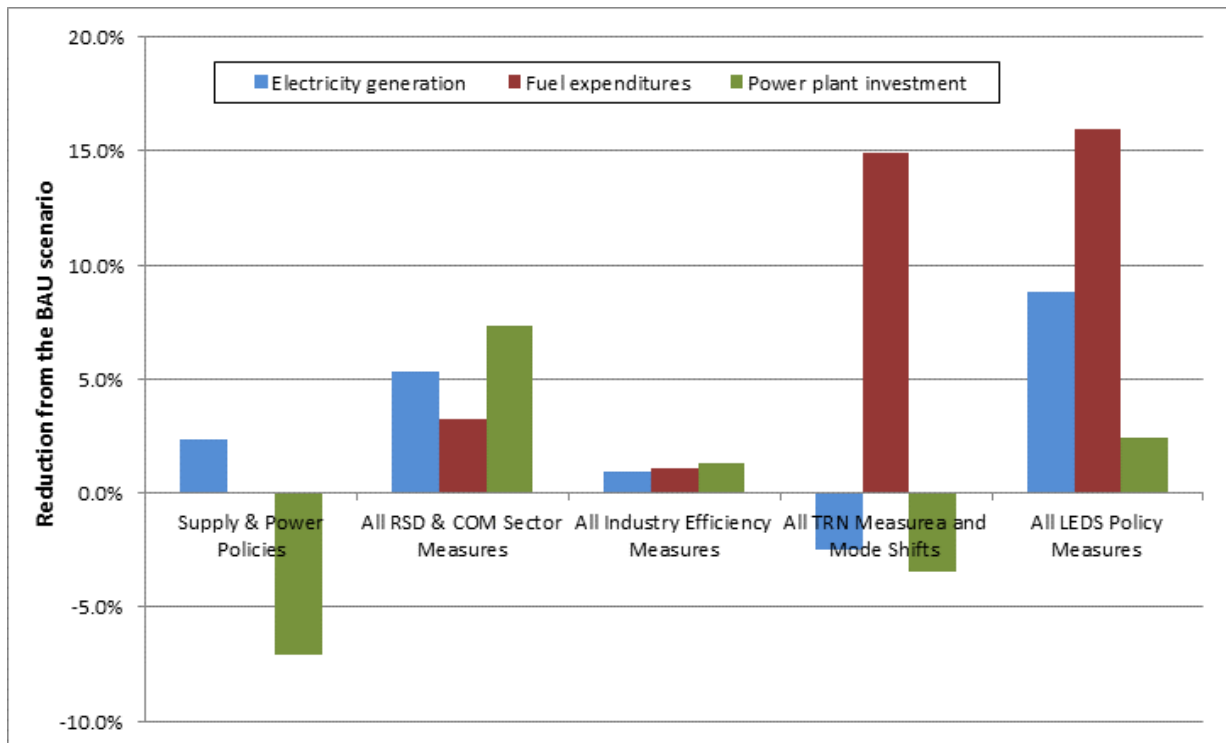


Figure 20: Sectoral and Combined LEDS Measure Impacts - 2

APPENDIX A: DETAILED RESULTS OF ALL LEDS MEASURES

A.1 - Supply and Power Sector

Indicator	Units	Reference	Reduced natural gas losses			More Eff Power Plants			Promote HPPs			Non-hydro Renewables			Supply & Power Policies		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,571	-88	-0.1%	58,675	16	0.0%	58,661	2	0.0%	58,713	54	0.1%	58,646	-13	0.0%
Primary Energy Supply -2030	Ktoe	9,770	9,671	-99	-1.0%	9,608	-162	-1.7%	9,665	-105	-1.1%	9,776	6	0.1%	9,380	-390	-4.0%
All Imports -2030	Ktoe	6,384	6,285	-99	-1.6%	6,221	-163	-2.5%	6,258	-127	-2.0%	6,384	0	0.0%	5,985	-399	-6.3%
Natural gas Imports	Ktoe	3,627	3,528	-99	-2.7%	3,465	-162	-4.5%	3,501	-126	-3.5%	3,627	0	0.0%	3,228	-399	-11.0%
Net Electricity Exports	Gwh	-13,529	-13,532	-3	0.0%	-13,532	-3	0.0%	-13,233	296	-2.2%	-13,604	-74	0.5%	-12,797	732	-5.4%
Electricity Generation	Gwh	31,380	31,383	3	0.0%	31,383	3	0.0%	31,087	-294	-0.9%	31,455	75	0.2%	30,647	-733	-2.3%
Fuel Expenditure - 2030	2014M€	2,773	2,737	-36	-1.3%	2,715	-58	-2.1%	2,742	-30	-1.1%	2,769	-4	-0.1%	2,669	-104	-3.8%
Power Plant Capacity -2030	GW	9	9	0	0.0%	9	0	-0.8%	9	0	1.5%	9	0	1.2%	9	0	0.5%
Hydro Power Plant Capacity -2030	GW	8	8	0	0.0%	8	0	0.0%	8	0	1.7%	8	0	-1.3%	8	0	-1.2%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.01	0	-6.5%	1.08	0	0.0%	1.08	0	0.0%	1.01	0	-6.5%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.22	0	966.2%	0.22	0	966.2%
Power Plant New Capacity (2014-2030)	GW	5.35	5.35	0	0.0%	5.85	1	9.4%	5.48	0.13	2.5%	5.45	0	1.9%	5.96	1	11.4%
Power Plant Investment Cost (2014-2030)	2014M€	8,049	8,050	1	0.0%	8,407	358	4.4%	8,293	244	3.0%	8,251	201	2.5%	8,622	573	7.1%
Total Final Energy - 2030	Ktoe	7,207	7,207	0	0.0%	7,207	0	0.0%	7,207	0	0.0%	7,207	0	0.0%	7,207	0	0.0%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,995	1	0.0%	15,629	-365	-2.3%	15,605	-389	-2.4%	15,994	0	0.0%	15,303	-691	-4.3%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,817	1	0.0%	2,817	0	0.0%	2,817	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,111	0	0.0%	1,746	-365	-17.3%	1,721	-389	-18.5%	2,111	0	0.0%	1,420	-690	-32.7%
Total Methane Emissions -2030	Kt	140	63	-77	-54.9%	135	-5	-3.7%	135	-5	-3.5%	140	0	0.0%	60	-80	-57.3%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	0.0%	0.32	0	-2.0%	0.32	0	-2.0%	0.33	0	0.0%	0.32	0	-3.7%
Total GHG emissions	Kt CO ₂ eq	19,025	17,411	-1,613	-8.5%	18,551	-474	-2.5%	18,533	-491	-2.6%	19,025	0	0.0%	16,649	-2,375	-12.5%

A.2 - Buildings Sector

Indicator	Units	Reference	INC bulb phaseout			Appliance Labeling			COM Public Building Retrofits			COM Building Retrofits			New RSD & COM Building Codes		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	57,953	-706	-1.2%	58,573	-85	-0.1%	58,657	-2	0.0%	58,626	-33	-0.1%	58,637	-22	0.0%
Primary Energy Supply -2030	Ktoe	9,770	9,607	-163	-1.7%	9,697	-73	-0.8%	9,764	-7	-0.1%	9,749	-21	-0.2%	9,738	-32	-0.3%
All Imports -2030	Ktoe	6,384	6,329	-55	-0.9%	6,362	-23	-0.4%	6,377	-7	-0.1%	6,362	-22	-0.3%	6,352	-32	-0.5%
Natural gas Imports	Ktoe	3,627	3,572	-55	-1.5%	3,605	-22	-0.6%	3,620	-7	-0.2%	3,605	-22	-0.6%	3,600	-27	-0.7%
Net Electricity Exports	Gwh	-13,529	-13,655	-125	0.9%	-13,509	21	-0.2%	-13,528	1	0.0%	-13,529	0	0.0%	-13,526	3	0.0%
Electricity Generation	Gwh	31,380	29,806	-1,574	-5.0%	30,657	-724	-2.3%	31,383	3	0.0%	31,389	9	0.0%	31,374	-6	0.0%
Fuel Expenditure - 2030	2014M€	2,773	2,746	-27	-1.0%	2,765	-8	-0.3%	2,770	-2	-0.1%	2,765	-8	-0.3%	2,760	-13	-0.5%
Power Plant Capacity -2030	GW	9	8	0	-3.4%	9	0	-1.6%	9	0	0.0%	9	0	0.0%	9	0	0.0%
Hydro Power Plant Capacity -2030	GW	8	7	0	-3.9%	8	0	-1.8%	8	0	0.0%	8	0	0.0%	8	0	0.0%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.05	0	-5.6%	5.21	0	-2.7%	5.35	0	0.0%	5.35	0	0.0%	5.35	0	0.0%
Power Plant Investment Cost (2014-2030)	2014M€	8,049.31	7,488.97	-560	-7.0%	7,785.11	-264	-3.3%	8,050.26	1	0.0%	8,052.54	3	0.0%	8,046.78	-3	0.0%
Total Final Energy - 2030	Ktoe	7,207	7,069	-137	-1.9%	7,150	-57	-0.8%	7,201	-6	-0.1%	7,187	-20	-0.3%	7,177	-30	-0.4%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,032	-60	-2.8%	2,076	-15	-0.7%	2,092	0	0.0%	2,092	0	0.0%	2,073	-19	-0.9%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,870	-124	-0.8%	15,943	-51	-0.3%	15,978	-16	-0.1%	15,944	-50	-0.3%	15,921	-73	-0.5%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,817	0	0.0%	2,817	1	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,771	-45	-1.6%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	1,986	-124	-5.9%	2,059	-51	-2.4%	2,111	0	0.0%	2,111	1	0.0%	2,110	0	0.0%
Total Methane Emissions -2030	Kt	140	138	-2	-1.2%	139	-1	-0.5%	140	0	-0.2%	139	-1	-0.5%	139	-1	-0.6%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	-0.7%	0.33	0	-0.3%	0.33	0	-0.1%	0.33	0	-0.3%	0.33	0	-0.4%
Total GHG emissions	Kt CO ₂ eq	19,025	18,864	-160	-0.8%	18,959	-66	-0.3%	19,004	-20	-0.1%	18,960	-65	-0.3%	18,933	-92	-0.5%

Indicator	Units	Reference	RSD Building NAMA			NAMA - ADV biomass heating stoves			NAMA - RSD solar water heating			COM Solar Water Heating		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,696	37	0.1%	58,735	76	0.1%	58,669	10	0.0%	58,664	5	0.0%
Primary Energy Supply -2030	Ktoe	9,770	9,724	-46	-0.5%	9,753	-17	-0.2%	9,772	2	0.0%	9,768	-2	0.0%
All Imports -2030	Ktoe	6,384	6,339	-45	-0.7%	6,368	-16	-0.3%	6,371	-13	-0.2%	6,376	-8	-0.1%
Natural gas Imports	Ktoe	3,627	3,592	-34	-0.9%	3,616	-11	-0.3%	3,621	-5	-0.2%	3,618	-8	-0.2%
Net Electricity Exports	Gwh	-13,529	-13,530	-1	0.0%	-13,522	8	-0.1%	-13,520	10	-0.1%	-13,529	0	0.0%
Electricity Generation	Gwh	31,380	31,370	-10	0.0%	31,370	-10	0.0%	31,422	42	0.1%	31,384	4	0.0%
Fuel Expenditure - 2030	2014M€	2,773	2,752	-20	-0.7%	2,765	-8	-0.3%	2,766	-7	-0.3%	2,770	-3	-0.1%
Power Plant Capacity -2030	GW	9	9	0	0.0%	9	0	0.0%	9	0	0.1%	9	0	0.0%
Hydro Power Plant Capacity-2030	GW	8	8	0	0.0%	8	0	0.0%	8	0	0.1%	8	0	0.0%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.35	0	0.0%	5.35	0	0.0%	5.36	0	0.1%	5.35	0	0.0%
Power Plant Investment Cost (2014-2030)	2014M€	8,049.31	8,045.82	-3	0.0%	8,044.93	-4	-0.1%	8,063.67	14	0.2%	8,050.84	2	0.0%
Total Final Energy - 2030	Ktoe	7,207	7,162	-44	-0.6%	7,191	-16	-0.2%	7,209	2	0.0%	7,206	-1	0.0%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,047	-44	-2.1%	2,076	-16	-0.8%	2,094	2	0.1%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,888	-106	-0.7%	15,955	-39	-0.2%	15,962	-32	-0.2%	15,975	-19	-0.1%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,711	-105	-3.7%	2,778	-39	-1.4%	2,780	-36	-1.3%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,110	-1	0.0%	2,110	0	0.0%	2,114	4	0.2%	2,111	0	0.0%
Total Methane Emissions -2030	Kt	140	139	-1	-0.8%	140	0	-0.3%	140	0	-0.1%	140	0	-0.2%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	-0.5%	0.33	0	-0.2%	0.33	0	-0.1%	0.33	0	-0.1%
Total GHG emissions	Kt CO ₂ eq	19,025	18,895	-130	-0.7%	18,978	-46	-0.2%	18,989	-36	-0.2%	19,000	-24	-0.1%

Indicator	Units	Reference	LED Public Lighting			Renewables, Appliance & Lighting Eff			All RSD & COM Building Retrofits			All RSD & COM Sector Measures		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,632	-27	0.0%	57,938	-721	-1.2%	58,621	-38	-0.1%	57,977	-682	-1.2%
Primary Energy Supply -2030	Ktoe	9,770	9,758	-12	-0.1%	9,510	-260	-2.7%	9,658	-112	-1.1%	9,473	-297	-3.0%
All Imports -2030	Ktoe	6,384	6,381	-3	-0.1%	6,261	-123	-1.9%	6,273	-111	-1.7%	6,179	-205	-3.2%
Natural gas Imports	Ktoe	3,627	3,623	-3	-0.1%	3,527	-100	-2.8%	3,532	-94	-2.6%	3,452	-175	-4.8%
Net Electricity Exports	Gwh	-13,529	-13,509	21	-0.2%	-13,596	-66	0.5%	-13,537	-8	0.1%	-13,642	-113	0.8%
Electricity Generation	Gwh	31,380	31,260	-120	-0.4%	29,129	-2,251	-7.2%	31,347	-33	-0.1%	29,720	-1,660	-5.3%
Fuel Expenditure - 2030	2014M€	2,773	2,772	0	0.0%	2,716	-57	-2.0%	2,726	-47	-1.7%	2,682	-91	-3.3%
Power Plant Capacity -2030	GW	9	9	0	-0.3%	8	0	-5.0%	9	0	-0.1%	8	0	-3.6%
Hydro Power Plant Capacity -2030	GW	8	8	0	-0.3%	7	0	-5.7%	8	0	-0.1%	7	0	-4.1%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.33	0	-0.5%	4.91	0	-8.2%	5.34	0	-0.1%	5.03	0	-6.0%
Power Plant Investment Cost (2014-2030)	2014M€	8,049.31	8,004.07	-45	-0.6%	7,238.55	-811	-10.1%	8,037.94	-11	-0.1%	7,456.84	-592	-7.4%
Total Final Energy - 2030	Ktoe	7,207	7,199	-8	-0.1%	6,992	-215	-3.0%	7,099	-108	-1.5%	6,943	-264	-3.7%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,005	-86	-4.1%	2,028	-64	-3.0%	1,955	-137	-6.5%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,987	-7	0.0%	15,710	-284	-1.8%	15,737	-257	-1.6%	15,523	-471	-2.9%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,721	-95	-3.4%	2,666	-151	-5.3%	2,573	-244	-8.7%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,103	-7	-0.3%	1,941	-169	-8.0%	2,108	-3	-0.1%	1,981	-129	-6.1%
Total Methane Emissions -2030	Kt	140	140	0	-0.1%	137	-3	-2.3%	137	-3	-2.2%	134	-6	-4.0%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	0.0%	0.33	0	-1.4%	0.33	0	-1.3%	0.32	0	-2.4%
Total GHG emissions	Kt CO ₂ eq	19,025	19,015	-9	0.0%	18,673	-352	-1.8%	18,702	-322	-1.7%	18,433	-592	-3.1%

A.3 - Industry Sector

Indicator	Units	Reference	Chemicals - Nitric Acid Cogeneration			Chemical - Advanced Motor Drives			Chemical - Efficient Burners for Ammonia			Food - Advanced Process heat			Food - Advanced Motor Drives		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,635	-24	0.0%	58,666	7	0.0%	58,646	-13	0.0%	58,654	-5	0.0%	58,665	6	0.0%
Primary Energy Supply -2030	Ktoe	9,770	9,763	-7	-0.1%	9,767	-3	0.0%	9,764	-6	-0.1%	9,760	-10	-0.1%	9,767	-3	0.0%
All Imports -2030	Ktoe	6,384	6,382	-2	0.0%	6,383	-1	0.0%	6,378	-6	-0.1%	6,375	-9	-0.1%	6,383	-1	0.0%
Natural gas Imports	Ktoe	3,627	3,624	-2	-0.1%	3,626	-1	0.0%	3,620	-6	-0.2%	3,617	-9	-0.3%	3,626	-1	0.0%
Net Electricity Exports	Gwh	-13,529	-13,531	-2	0.0%	-13,528	1	0.0%	-13,529	0	0.0%	-13,529	0	0.0%	-13,528	1	0.0%
Electricity Generation	Gwh	31,380	31,315	-66	-0.2%	31,354	-27	-0.1%	31,380	0	0.0%	31,378	-2	0.0%	31,354	-26	-0.1%
Fuel Expenditure - 2030	2014M€	2,773	2,772	-1	0.0%	2,772	0	0.0%	2,770	-2	-0.1%	2,769	-3	-0.1%	2,772	0	0.0%
Power Plant Capacity -2030	GW	9	9	0	-0.1%	9	0	-0.1%	9	0	0.0%	9	0	0.0%	9	0	-0.1%
Hydro Power Plant Capacity -2030	GW	8	8	0	-0.2%	8	0	-0.1%	8	0	0.0%	8	0	0.0%	8	0	-0.1%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.34	0	-0.2%	5.34	0	-0.1%	5.35	0	0.0%	5.35	0	0.0%	5.34	0	-0.1%
Power Plant Investment Cost (2014-2030)	2014M€	8,049.31	8,025.65	-24	-0.3%	8,039.54	-10	-0.1%	8,049.34	0	0.0%	8,048.58	-1	0.0%	8,039.63	-10	-0.1%
Total Final Energy - 2030	Ktoe	7,207	7,201	-6	-0.1%	7,205	-2	0.0%	7,201	-6	-0.1%	7,197	-10	-0.1%	7,205	-2	0.0%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,463	-6	-0.4%	1,466	-2	-0.1%	1,462	-6	-0.4%	1,459	-10	-0.7%	1,466	-2	-0.1%
Total CO ₂ Emissions - 2030	Kt	15,994	15,989	-5	0.0%	15,992	-2	0.0%	15,979	-15	-0.1%	15,970	-24	-0.1%	15,992	-2	-0.01%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,447	-15	-0.4%	3,438	-23	-0.7%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,106	-5	-0.2%	2,109	-2	-0.1%	2,111	0	0.0%	2,111	0	0.0%	2,109	-2	-0.1%
Total Methane Emissions -2030	Kt	140	140	0	-0.1%	140	0	0.0%	140	0	-0.1%	140	0	-0.2%	140	0	0.0%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	0.0%	0.33	0	0.0%	0.33	0	-0.1%	0.33	0	-0.1%	0.33	0	0.0%
Total GHG emissions	Kt CO ₂ eq	19,025	19,018	-6	0.0%	19,022	-2	0.0%	19,006	-19	-0.1%	18,994	-30	-0.2%	19,022	-2	-0.01%

Indicator	Units	Cement - Motor Drive Eff				Cement - Heat Recycling Imp			Cement - Wet-to-Dry Process			Iron&Steel - Process heat Imp			Iron&Steel - Motor Drive Eff		
		Reference	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,666	8	0.0%	58,659	-0.305	0.00%	58,525	-134	-0.2%	58,635	-24	0.0%	58,665	7	0.0%
Primary Energy Supply -2030	Ktoe	9,770	9,767	-3	0.0%	9,770	-0.117	0.00%	9,668	-102	-1.0%	9,757	-13	-0.1%	9,767	-3	0.0%
All Imports -2030	Ktoe	6,384	6,383	-1	0.0%	6,384	-0.124	0.00%	6,345	-40	-0.6%	6,380	-4	-0.1%	6,383	-1	0.0%
Natural gas Imports	Ktoe	3,627	3,626	-1	0.0%	3,626	-0.124	-0.00342%	3,627	0	0.0%	3,622	-4	-0.1%	3,626	-1	0.0%
Net Electricity Exports	Gwh	-13,529	-13,528	1	0.0%	-13,529	0.000	0.0%	-13,529	0	0.0%	-13,533	-4	0.0%	-13,528	1	0.0%
Electricity Generation	Gwh	31,380	31,350	-30	-0.1%	31,380	0.083	0.0%	31,380	0	0.0%	31,258	-122	-0.4%	31,354	-26	-0.1%
Fuel Expenditure - 2030	2014M€	2,773	2,772	0	0.0%	2,773	-0.045	0.0%	2,752	-21	-0.8%	2,771	-2	-0.1%	2,772	0	0.0%
Power Plant Capacity -2030	GW	9	9	0	-0.1%	9	0.000	0.0%	9	0	0.0%	9	0	-0.3%	9	0	-0.1%
Hydro Power Plant Capacity -2030	GW	8	8	0	-0.1%	8	0.000	0.0%	8	0	0.0%	8	0	-0.3%	8	0	-0.1%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0.000	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0.000	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.34	0	-0.1%	5.35	0.000	0.0%	5.35	0	0.0%	5.33	0	-0.4%	5.34	0	-0.1%
Power Plant Investment Cost (2014-2030)	2014M€	8,049.31	8,038.37	-11	-0.1%	8,049.34	0.035	0.0%	8,049.34	0	0.0%	8,005.23	-44	-0.5%	8,039.76	-10	-0.1%
Total Final Energy - 2030	Ktoe	7,207	7,205	-2	0.0%	7,207	-0.120	0.0%	7,105	-102	-1.4%	7,197	-10	-0.1%	7,205	-2	0.0%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0.000	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0.000	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,466	-2	-0.2%	1,468	-0.122	-0.008%	1,366	-102	-6.9%	1,458	-10	-0.7%	1,466	-2	-0.1%
Total CO ₂ Emissions - 2030	Kt	15,994	15,992	-2	-0.01%	15,994	-0.280	0.00%	15,581	-413	-2.6%	15,985	-9	-0.1%	15,992	-2	0.0%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0.000	0.00%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,816	0.000	0.00%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	-0.285	-0.01%	3,049	-413	-11.9%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,109	-2	-0.1%	2,111	0.006	0.00%	2,111	0	0.0%	2,101	-9	-0.4%	2,109	-2	-0.1%
Total Methane Emissions -2030	Kt	140	140	0	0.0%	140	-0.004	0.00%	138	-2	-1.5%	140	0	-0.1%	140	0	0.0%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	0.0%	0.33	0.000	0.00%	0.32	0	-1.8%	0.33	0	0.0%	0.33	0	0.0%
Total GHG emissions	Kt CO ₂ eq	19,025	19,022	-3	-0.01%	19,024	-0.365	-0.002%	18,567	-458	-2.4%	19,013	-12	-0.1%	19,022	-2	0.0%

Indicator	Units	Reference	Iron&Steel - Automated Controls			Pig Iron Industry - 2020			All Industry Advanced Motor Drive Measures			All Industry Efficiency Measures		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,659	-0.1	0.00%	59,210	551	0.9%	58,685	26	0.0%	58,485	-174	-0.3%
Primary Energy Supply -2030	Ktoe	9,770	9,770	0.0	0.00%	9,980	210	2.1%	9,759	-11	-0.1%	9,621	-149	-1.5%
All Imports -2030	Ktoe	6,384	6,384	0.0	0.00%	6,594	210	3.3%	6,381	-3	-0.1%	6,319	-65	-1.0%
Natural gas Imports	Ktoe	3,627	3,627	0.0	0.00%	3,627	0	0.0%	3,623	-3	-0.1%	3,602	-25	-0.7%
Net Electricity Exports	Gwh	-13,529	-13,529	0.0	0.00%	-13,529	0	0.0%	-13,524	5	0.0%	-13,533	-3	0.0%
Electricity Generation	Gwh	31,380	31,380	0.1	0.00%	31,380	0	0.0%	31,271	-110	-0.3%	31,083	-297	-0.9%
Fuel Expenditure - 2030	2014M€	2,773	2,773	0.0	0.00%	2,851	78	2.8%	2,772	-1	0.0%	2,742	-30	-1.1%
Power Plant Capacity -2030	GW	9	9	0.0	0.00%	9	0	0.0%	9	0	-0.2%	9	0	-0.7%
Hydro Power Plant Capacity -2030	GW	8	8	0.0	0.00%	8	0	0.0%	8	0	-0.3%	8	0	-0.8%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0.0	0.00%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0.0	0.00%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.35	0.0	0.00%	5.35	0	0.0%	5.33	0	-0.4%	5.29	0	-1.1%
Power Plant Investment Cost (2014-2030)	2014M€	8,049.31	8,049.34	0.0	0.00%	8,049.34	0	0.0%	8,009.16	-40	-0.5%	7,941.88	-107	-1.3%
Total Final Energy - 2030	Ktoe	7,207	7,207	-0.1	0.00%	7,417	210	2.9%	7,198	-8	-0.1%	7,065	-142	-2.0%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0.0	0.00%	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0.0	0.00%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	-0.1	0.00%	1,678	210	14.3%	1,460	-8	-0.6%	1,326	-142	-9.7%
Total CO ₂ Emissions - 2030	Kt	15,994	15,994	-0.2	0.00%	16,926	932	5.8%	15,986	-8	0.0%	15,522	-472	-3.0%
Transport sector CO2 Emissions - 2030	Kt	6,709	6,709	0.0	0.00%	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%
Buildings sector CO2 Emissions - 2030	Kt	2,816	2,816	0.0	0.00%	2,816	0	0.0%	2,816	0	0.0%	2,817	1	0.0%
Industry sector CO2 Emissions - 2030	Kt	3,461	3,461	-0.2	-0.01%	4,393	932	26.9%	3,461	0	0.0%	3,010	-451	-13.0%
Power sector CO2 Emissions - 2030	Kt	2,111	2,111	0.0	0.00%	2,111	0	0.0%	2,103	-8	-0.4%	2,089	-22	-1.0%
Total Methane Emissions -2030	Kt	140	140	0.0	0.00%	140	0	0.0%	140	0	-0.1%	137	-3	-2.0%
Total N2O Emissions -2030	Kt	0.33	0.33	0.0	0.00%	0.34	0	3.7%	0.33	0	0.0%	0.32	0	-2.1%
Total GHG emissions	Kt CO2 eq	19,025	19,024	-0.23	0.00%	19,961	936	4.9%	19,015	-10	-0.1%	18,490	-535	-2.8%

A.4 - Transport Sector

Indicator	Units	Reference	Biofuel supply & 6% target in 2030			Improved LDV stock and fuel standards			Increase Road Transport Efficiency			Hybrid and Electric vehicle targets		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,691	32	0.1%	58,595	-63	-0.1%	58,555	-104	-0.2%	58,831	172	0.3%
Primary Energy Supply -2030	Ktoe	9,770	9,779	9	0.1%	9,742	-28	-0.3%	9,724	-46	-0.5%	9,682	-88	-0.9%
All Imports -2030	Ktoe	6,384	6,372	-12	-0.2%	6,356	-28	-0.4%	6,338	-46	-0.7%	6,272	-112	-1.7%
Natural gas Imports	Ktoe	3,627	3,627	0	0.0%	3,610	-17	-0.5%	3,606	-20	-0.6%	3,560	-67	-1.8%
Net Electricity Exports	Gwh	-13,529	-13,529	0	0.0%	-13,529	0	0.0%	-13,529	0	0.0%	-13,537	-7	0.1%
Electricity Generation	Gwh	31,380	31,380	0	0.0%	31,380	0	0.0%	31,380	0	0.0%	31,721	341	1.1%
Fuel Expenditure - 2030	2014M€	2,773	2,778	5	0.2%	2,755	-17	-0.6%	2,741	-32	-1.1%	2,704	-69	-2.5%
Power Plant Capacity -2030	GW	9	9	0	0.0%	9	0	0.0%	9	0	0.0%	9	0	0.8%
Hydro Power Plant Capacity -2030	GW	8	8	0	0.0%	8	0	0.0%	8	0	0.0%	8	0	0.9%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.35	0	0.0%	5.35	0	0.0%	5.35	0	0.0%	5.42	0	1.2%
Power Plant Investment Cost (2014-2030)	2014M€	8,049	8,049	0	0.0%	8,049	0	0.0%	8,049	0	0.0%	8,173	124	1.5%
Total Final Energy - 2030	Ktoe	7,207	7,207	0	0.0%	7,179	-28	-0.4%	7,162	-45	-0.6%	7,115	-92	-1.3%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,703	-28	-1.0%	2,685	-45	-1.7%	2,638	-92	-3.4%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,588	-406	-2.5%	15,923	-71	-0.4%	15,871	-123	-0.8%	15,716	-278	-1.7%
Transport sector CO2 Emissions - 2030	Kt	6,709	6,303	-406	-6.1%	6,638	-71	-1.1%	6,586	-123	-1.8%	6,406	-303	-4.5%
Buildings sector CO2 Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO2 Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO2 Emissions - 2030	Kt	2,111	2,111	0	0.0%	2,111	0	0.0%	2,111	0	0.0%	2,135	24	1.2%
Total Methane Emissions -2030	Kt	140	140	0	-0.1%	139	-1	-0.4%	139	-1	-0.5%	138	-2	-1.7%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	-1.1%	0.33	0	-0.3%	0.33	0	-0.5%	0.33	0	-1.2%
Total GHG emissions	Kt CO ₂ eq	19,025	18,615	-409	-2.2%	18,941	-83	-0.4%	18,887	-138	-0.7%	18,696	-329	-1.7%

Indicator	Units	Reference	Taxi Regulations			Promote Public Parking			Promote Urban Cycling & Walking			Promote 2-wheelers		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	57,458	-1,201	-2.0%	58,609	-50	-0.1%	58,283	-376	-0.6%	58,765	106	0.2%
Primary Energy Supply -2030	Ktoe	9,770	9,728	-42	-0.4%	9,765	-5	-0.1%	9,728	-42	-0.4%	9,750	-20	-0.2%
All Imports -2030	Ktoe	6,384	6,342	-42	-0.7%	6,379	-5	-0.1%	6,343	-42	-0.7%	6,364	-20	-0.3%
Natural gas Imports	Ktoe	3,627	3,608	-19	-0.5%	3,624	-3	-0.1%	3,608	-19	-0.5%	3,610	-17	-0.5%
Net Electricity Exports	Gwh	-13,529	-13,529	0	0.0%	-13,529	0	0.0%	-13,529	0	0.0%	-13,529	0	0.0%
Electricity Generation	Gwh	31,380	31,380	-1	0.0%	31,380	0	0.0%	31,380	0	0.0%	31,380	0	0.0%
Fuel Expenditure - 2030	2014M€	2,773	2,743	-30	-1.1%	2,769	-4	-0.1%	2,744	-29	-1.1%	2,764	-9	-0.3%
Power Plant Capacity -2030	GW	9	9	0	0.0%	9	0	0.0%	9	0	0.0%	9	0	0.0%
Hydro Power Plant Capacity -2030	GW	8	8	0	0.0%	8	0	0.0%	8	0	0.0%	8	0	0.0%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.35	0	0.0%	5.35	0	0.0%	5.35	0	0.0%	5.35	0	0.0%
Power Plant Investment Cost (2014-2030)	2014M€	8,049	8,049	0	0.0%	8,049	0	0.0%	8,049	0	0.0%	8,049	0	0.0%
Total Final Energy - 2030	Ktoe	7,207	7,166	-41	-0.6%	7,202	-5	-0.1%	7,166	-41	-0.6%	7,188	-19	-0.3%
Transport Final Energy - 2030	Ktoe	2,731	2,689	-41	-1.5%	2,725	-5	-0.2%	2,690	-41	-1.5%	2,712	-19	-0.7%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,884	-109	-0.7%	15,980	-14	-0.1%	15,886	-108	-0.7%	15,948	-46	-0.3%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,599	-109	-1.6%	6,695	-14	-0.2%	6,601	-108	-1.6%	6,662	-46	-0.7%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,111	0	0.0%	2,111	0	0.0%	2,111	0	0.0%	2,111	0	0.0%
Total Methane Emissions -2030	Kt	140	139	-1	-0.5%	140	0	-0.1%	139	-1	-0.5%	139	-1	-0.4%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	-0.4%	0.33	0	-0.1%	0.33	0	-0.4%	0.33	0	-0.2%
Total GHG emissions	Kt CO ₂ eq	19,025	18,901	-124	-0.7%	19,009	-16	-0.1%	18,903	-122	-0.6%	18,966	-59	-0.3%

Indicator	Units	Reference	Promote Urban Public Transport			Promote CNG Buses			Improved Intercity Rail			Promote Inter-city Bus Transport		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,523	-136	-0.2%	58,652	-7	0.0%	58,185	-474	-0.8%	58,516	-143	-0.2%
Primary Energy Supply - 2030	Ktoe	9,770	9,756	-14	-0.1%	9,774	4	0.0%	9,733	-37	-0.4%	9,749	-21	-0.2%
All Imports -2030	Ktoe	6,384	6,370	-14	-0.2%	6,388	4	0.1%	6,324	-60	-0.9%	6,363	-21	-0.3%
Natural gas Imports	Ktoe	3,627	3,617	-9	-0.3%	3,640	14	0.4%	3,606	-21	-0.6%	3,615	-11	-0.3%
Net Electricity Exports	Gwh	-13,529	-13,529	0	0.0%	-13,529	0	0.0%	-13,534	-5	0.0%	-13,529	0	0.0%
Electricity Generation	Gwh	31,380	31,381	1	0.0%	31,380	0	0.0%	31,720	340	1.1%	31,380	0	0.0%
Fuel Expenditure - 2030	2014M€	2,773	2,764	-9	-0.3%	2,768	-4	-0.2%	2,726	-47	-1.7%	2,758	-14	-0.5%
Power Plant Capacity -2030	GW	9	9	0	0.0%	9	0	0.0%	9	0	0.8%	9	0	0.0%
Hydro Power Plant Capacity -2030	GW	8	8	0	0.0%	8	0	0.0%	8	0	0.9%	8	0	0.0%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.35	0	0.0%	5.35	0	0.0%	5.42	0	1.2%	5.35	0	0.0%
Power Plant Investment Cost (2014-2030)	2014M€	8,049	8,050	0	0.0%	8,049	0	0.0%	8,173	124	1.5%	8,049	0	0.0%
Total Final Energy - 2030	Ktoe	7,207	7,193	-14	-0.2%	7,210	3	0.0%	7,164	-43	-0.6%	7,186	-21	-0.3%
Transport Final Energy - 2030	Ktoe	2,731	2,717	-14	-0.5%	2,734	3	0.1%	2,688	-43	-1.6%	2,710	-21	-0.8%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,961	-33	-0.2%	15,994	0	0.0%	15,832	-162	-1.0%	15,940	-54	-0.3%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,675	-33	-0.5%	6,708	-0.108	0.0%	6,522	-186	-2.8%	6,655	-54	-0.8%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,111	0	0.0%	2,111	0	0.0%	2,135	24	1.2%	2,111	0	0.0%
Total Methane Emissions -2030	Kt	140	140	0	-0.2%	140	0	0.3%	139	-1	-0.5%	140	0	-0.3%
Total N ₂ O Emissions -2030	Kt	0.33	0.33	0	-0.2%	0.33	0	0.1%	0.33	0	-0.5%	0.33	0	-0.2%
Total GHG emissions	Kt CO ₂ eq	19,025	18,984	-40	-0.2%	19,034	10	0.1%	18,846	-178	-0.9%	18,963	-62	-0.3%

Indicator	Units	Reference	HGV mode shift to Rail Freight			All Non-Mode-Shift TRN Measures			Combined TRN Mode Shifts			All TRN Measures and Mode Shifts		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	56,374	-2,285	-3.9%	56,453	-2,206	-3.8%	56,558	-2,101	-3.6%	54,323	-4,336	-7.4%
Primary Energy Supply -2030	Ktoe	9,770	9,550	-220	-2.3%	9,483	-287	-2.9%	9,588	-182	-1.9%	9,272	-498	-5.1%
All Imports -2030	Ktoe	6,384	6,151	-233	-3.7%	6,067	-317	-5.0%	6,179	-206	-3.2%	5,832	-552	-8.6%
Natural gas Imports	Ktoe	3,627	3,590	-36	-1.0%	3,578	-49	-1.3%	3,528	-99	-2.7%	3,438	-188	-5.2%
Net Electricity Exports	Gwh	-13,529	-13,545	-16	0.1%	-13,546	-17	0.1%	-13,534	-5	0.0%	-13,533	-3	0.0%
Electricity Generation	Gwh	31,380	31,560	179	0.6%	31,806	426	1.4%	31,719	339	1.1%	32,150	769	2.5%
Fuel Expenditure - 2030	2014M€	2,773	2,576	-197	-7.1%	2,502	-271	-9.8%	2,631	-141	-5.1%	2,358	-414	-14.9%
Power Plant Capacity -2030	GW	9	9	0	0.4%	9	0	1.0%	9	0	0.8%	9	0	1.7%
Hydro Power Plant Capacity -2030	GW	8	8	0	0.5%	8	0	1.1%	8	0	0.9%	8	0	2.0%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%
Renewable Power Plant Capacity-2030	GW	0.02	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%
Power Plant New Capacity (2014-2030)	GW	5.35	5.39	0	0.7%	5.43	0	1.6%	5.42	0	1.2%	5.50	0	2.8%
Power Plant Investment Cost (2014-2030)	2014M€	8,049	8,116	66	0.8%	8,205	156	1.9%	8,173	123	1.5%	8,329	279	3.5%
Total Final Energy - 2030	Ktoe	7,207	6,983	-224	-3.1%	6,912	-295	-4.1%	7,022	-185	-2.6%	6,701	-506	-7.0%
Transport Final Energy - 2030	Ktoe	2,731	2,507	-224	-8.2%	2,436	-295	-10.8%	2,546	-185	-6.8%	2,225	-506	-18.5%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%	2,092	0	0.0%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%	1,468	0	0.0%
Total CO ₂ Emissions - 2030	Kt	15,994	15,308	-686	-4.3%	15,070	-924	-5.8%	15,466	-528	-3.3%	14,483	-1,511	-9.4%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,011	-698	-10.4%	5,755	-953	-14.2%	6,156	-553	-8.2%	5,141	-1,567	-23.4%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%	2,816	0	0.0%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%	3,461	0	0.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	2,123	12	0.6%	2,141	30	1.4%	2,135	24	1.2%	2,167	56	2.7%
Total Methane Emissions -2030	Kt	140	139	-1	-0.9%	138	-2	-1.3%	136	-3	-2.5%	133	-7	-4.7%
Total N ₂ O Emissions -2030	Kt	0.33	0.32	0	-2.0%	0.32	0	-2.6%	0.32	0	-2.0%	0.31	0	-5.1%
Total GHG emissions	Kt CO ₂ eq	19,025	18,310	-715	-3.8%	18,061	-964	-5.1%	18,421	-603	-3.2%	17,369	-1,656	-8.7%

A.5 - Combined Sectoral Measures

Indicator	Units	Reference	Supply & Power Policies			All RSD & COM Sector Measures			All Industry Efficiency Measures			All TRN Measurea and Mode Shifts			All LEDS Policy Measures		
			Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)	Absolute value	Difference	Difference (%)
Total Discounted Energy System Cost (2014-2030)	2014M€	58,659	58,646	-13	0.0%	57,977	-682	-1.2%	58,485	-174	-0.3%	54,323	-4,336	-7.4%	55,657	-3,002	-5.1%
Primary Energy Supply -2030	Ktoe	9,770	9,380	-390	-4.0%	9,473	-297	-3.0%	9,621	-149	-1.5%	9,272	-498	-5.1%	8,621	-1,149	-11.8%
All Imports -2030	Ktoe	6,384	5,985	-399	-6.3%	6,179	-205	-3.2%	6,319	-65	-1.0%	5,832	-552	-8.6%	5,416	-969	-15.2%
Natural gas Imports	Ktoe	3,627	3,228	-399	-11.0%	3,452	-175	-4.8%	3,602	-25	-0.7%	3,438	-188	-5.2%	2,890	-736	-20.3%
Net Electricity Exports	Gwh	-13,529	-12,797	732	-5.4%	-13,642	-113	0.8%	-13,533	-3	0.0%	-13,533	-3	0.0%	-13,025	504	-3.7%
Electricity Generation	Gwh	31,380	30,647	-733	-2.3%	29,720	-1,660	-5.3%	31,083	-297	-0.9%	32,150	769	2.5%	28,602	-2,778	-8.9%
Fuel Expenditure - 2030	2014M€	2,773	2,773	0	0.0%	2,682	-91	-3.3%	2,742	-30	-1.1%	2,358	-414	-14.9%	2,331	-441	-15.9%
Power Plant Capacity -2030	GW	9	9	0	0.5%	8	0	-3.6%	9	0	-0.7%	9	0	1.7%	8	0	-4.3%
Hydro Power Plant Capacity -2030	GW	8	8	0	-1.2%	7	0	-4.1%	8	0	-0.8%	8	0	2.0%	7	-1	-6.6%
Thermal (gas and coal) Power Plant Capacity-2030	GW	1.08	1.01	0	-6.5%	1.08	0	0.0%	1.08	0	0.0%	1.08	0	0.0%	1.01	0	-6.5%
Renewable Power Plant Capacity-2030	GW	0.02	0.22	0	966.2%	0.02	0	0.0%	0.02	0	0.0%	0.02	0	0.0%	0.22	0	966.2%
Power Plant New Capacity (2014-2030)	GW	5.35	5.96	1	11.4%	5.03	0	-6.0%	5.29	-0.06	-1.1%	5.50	0	2.8%	5.55	0	3.7%
Power Plant Investment Cost (2014-2030)	2014M€	8,049	8,622	573	7.1%	7,457	-592	-7.4%	7,942	-107	-1.3%	8,329	279	3.5%	7,852	-198	-2.5%
Total Final Energy - 2030	Ktoe	7,207	7,207	0	0.0%	6,943	-264	-3.7%	7,065	-142	-2.0%	6,701	-506	-7.0%	6,471	-736	-10.2%
Transport Final Energy - 2030	Ktoe	2,731	2,731	0	0.0%	2,731	0	0.0%	2,731	0	0.0%	2,225	-506	-18.5%	2,442	-288	-10.6%
Buildings Sector Final Energy - 2030	Ktoe	2,092	2,092	0	0.0%	1,955	-137	-6.5%	2,092	0	0.0%	2,092	0	0.0%	1,954	-137	-6.6%
Industry Final Energy - 2030	Ktoe	1,468	1,468	0	0.0%	1,468	0	0.0%	1,326	-142	-9.7%	1,468	0	0.0%	1,326	-142	-9.7%
Total CO ₂ Emissions - 2030	Kt	15,994	15,303	-691	-4.3%	15,523	-471	-2.9%	15,522	-472	-3.0%	14,483	-1,511	-9.4%	13,556	-2,438	-15.2%
Transport sector CO ₂ Emissions - 2030	Kt	6,709	6,709	0	0.0%	6,709	0	0.0%	6,709	0	0.0%	5,141	-1,567	-23.4%	5,822	-887	-13.2%
Buildings sector CO ₂ Emissions - 2030	Kt	2,816	2,816	0	0.0%	2,573	-244	-8.7%	2,817	1	0.0%	2,816	0	0.0%	2,630	-187	-6.6%
Industry sector CO ₂ Emissions - 2030	Kt	3,461	3,461	0	0.0%	3,461	0	0.0%	3,010	-451	-13.0%	3,461	0	0.0%	3,010	-451	-13.0%
Power sector CO ₂ Emissions - 2030	Kt	2,111	1,420	-690	-32.7%	1,981	-129	-6.1%	2,089	-22	-1.0%	2,167	56	2.7%	1,296	-815	-38.6%
Total Methane Emissions -2030	Kt	140	60	-80	-57.3%	134	-6	-4.0%	137	-3	-2.0%	133	-7	-4.7%	53	-87	-61.8%
Total N ₂ O Emissions -2030	Kt	0.33	0.32	0	-3.7%	0.32	0	-2.4%	0.32	0	-2.1%	0.31	0	-5.1%	0.29	0	-11.3%
Total GHG emissions	Kt CO ₂ eq	19,025	16,649	-2,375	-12.5%	18,433	-592	-3.1%	18,490	-535	-2.8%	17,369	-1,656	-8.7%	14,763	-4,262	-22.4%